ELECTRICAL ENGINEERING

FEBRUARY 1956

Vol. 75, No. 2

Published monthly by American Institute of Electrical Engineers

Contents

Current Practices in Classifying Area for Electrical Installations *L. M. Goldsmith*
A procedure for determining the extent of hazardous areas gives industry a workable sound recommended practice for electrical installations 121

Considerations of Microwave Installations *R. G. McLaughlin*
Through use of a detailed example of a typical microwave installation, the principles of microwave propagation are outlined 126

The Physics of Magnetic Materials *R. M. Bozorth*
Explanations of the many phenomena of magnetic materials brings forth a number of practical engineering developments 134

Extruded High-Strength Aluminum for Electrical Bus Conductors *W. Switney, C. L. Carlson*
A discussion of the uses and electrical properties of extruded and heat-treated aluminum for electrical bus conductors 142

Location and Design of Distribution Substations in Residential Areas *J. W. Erven, C. S. Fiske, P. F. Hargreaves, E. M. Hunter, P. R. Pierson, O. J. Rotty*
Special considerations, such as appearance and noise, must be given to the design of substations in residential areas 148

Roll Welding Precious Metals for Telephone Contacts *A. L. Quinlan*
Advantages of this process include a saving of precious metal and lower production costs. The weldability of a design can be determined 154

Large-Area Photoconductive X-ray Pickup Tube Performance *J. E. Jacobs, Harold Berger*
General characteristics and detection sensitivity of the tube, as well as its industrial applications are presented 158

IN EDUCATIONAL CIRCLES 162

Beyond Engineering *M. D. Hooven* 162

"The Difficulties Young Men Have to Contend with..." *W. B. Morton* 165

The Graduate Engineer—His Training and Utilization in Industry *S. B. Ingram* 167

An Analysis of the Linear Pulsed Oscillator *M. C. Biedebach* 171

The Linear Pulse Stretching Circuit *Arvin Grabel* 176

A New Educational Program in Energy Conversion *G. S. Brown, A. Kusko, D. C. White* 180

Notes in Educational Circles 186

CONTENTS CONTINUED

THE COVER: A molten metal charge is poured from a 3,000-pound induction air melting furnace. A 4-ton jib crane tilts the furnace while the overhead crane supports the ladle.

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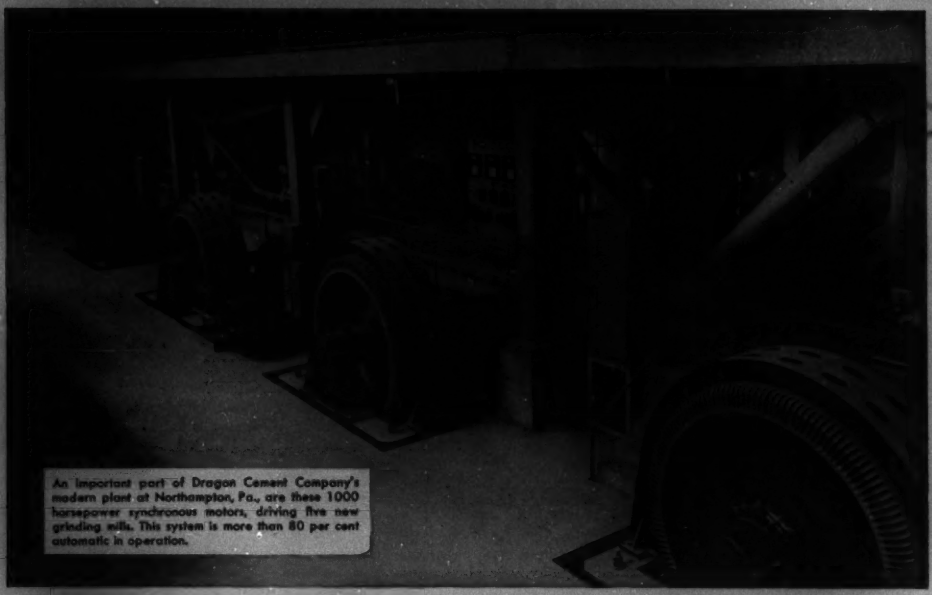

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Contents Continued . . .

Technical Paper Digests

General Study of Area Supply Methods — *J. A. Casazza, J. R. Rankin* — 131
Forecasting the Demand for Electricity — *R. G. Hooke* — 132
Future Application Needs of Carrier Pilot Relaying — *T. A. Cramer, F. C. Krings* — 133
Calculating Response to Arbitrary Input — *G. A. Biernson* — 141
An Evaluation of Butyl Rubber Insulated Cable — *J. C. Carroll, A. R. Lee, R. B. McKinley* — 146
Digital Calculation of Network Impedance — *A. F. Glimn, R. Habermann, Jr., J. M. Henderson, L. K. Kirchmayer* — 147

News Index

Institute Activities — 191
AIEE South West District Meeting To Be Held April 2–4 in Dallas, Tex. — 191
Transistor Circuits Conference Scheduled February 16–17 in Philadelphia — 192
Conference on Instrumentation To Be Held in Boston April 26–27 — 192
Western Computer Conference Will Be Held February 7–9 in California — 193
Future Meetings — 194
Varied Program Planned for AIEE North Eastern District Meeting — 194
Conference Paper Open for Discussion — 195
New York Section Honors AIEE Fellows — 196
Committee Activities — 196
Personalities — 198
Obituaries — 200
Membership — 201

Of Current Interest — 202
Metals Pilot Plant Answers New Alloys Needs — 202
Nuclear Congress and Exposition Show Peacetime Uses of Atomic Power — 204
Future Meetings of Other Societies — 205
Television Transmitters Erupt from Mount Popocatepetl Volcano — 206
AEC Special Courses and Fellowships Announced — 206
Polio Vaccine Virus Killing Device Developed — 207
First Test of Smallest "Atom Smasher" — 208
Joint Fellowships in Systems Engineering Announced — 209
Doctors and Engineers Study Bone and Metal Splints — 209
U. S. Navy Reveals Mark 63 Gunfire Control — 210
Electrodes Implanted in Brain for Study by Scientist — 211
U. S. Army Purchases "Bizmac" for $4 Million — 211
Display Previews All-Electronic Hotel — 212
Industrial Television Transmitted via Telephone — 212
New Books — 213
Pamphlets — 214

Industrial Notes — 18A

New Products — 26A

Trade Literature — 62A

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Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Headquarters
33 West 39th Street
New York 18, N. Y.

Founded 1884

Editorial Offices
500 Fifth Avenue
New York 36, N. Y.

M. D. HOOVEN, President — N. S. HIBSHMAN, Secretary

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ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 36, N. Y. Subscription $12 per year plus extra postage to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. February 1956, Vol. 75, No. 2. Number of copies of this issue 64,900

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Current Practices in Classifying Areas for Electrical Installations

L. M. GOLDSMITH
FELLOW AIEE

The American Petroleum Institute recently became interested in developing a procedure for determining the existence, classification, and extent of hazardous areas in petroleum refineries. As a result, for the first time they have given to industry a workable sound recommended practice for electric installations in hazardous areas that is not subject only to interpretation of the written word, but to the application of the problem through charts that give a graphic solution.

A DISCUSSION of current practices in classified areas for electrical installations first should include electrical engineering's contribution to oil. Perhaps the best example is in the petroleum refining industry where 40 years ago there were 674,840 barrels of crude oil per day charged to what were then called "stills," and the consumption of electricity was 1 kwhr per barrel, or 674,840 kwhr were consumed daily. Today, with 6.93-million barrels charged to refining equipment per day and 4.85 kwhr per barrel, the total daily consumption for the petroleum refining industry alone is 33.61-million kwhrs. This is an increase in the use of electricity in the industry of 5,000 per cent in 40 years.

DANGEROUS HAZARDS

THIS RAPIDLY INCREASING USE of electric power in the petroleum industry, as well as the relatively higher costs of special equipment and skilled labor, emphasize the need for clear understanding of the requirements for safe economical design. The presence of combustible materials introduces problems that are not encountered in most electric installations. Special precautions are required to insure that electric installations for the petroleum industry do not create dangerous hazards, such as fire and explosion. This concern over the fire and explosion aspects has tended to obscure the fact that electrical installations present other types of hazards of an equally serious nature. In the oil industry the hazards are: (1) fire and explosion; (2) electric shock; and (3) power failure.

It is difficult and pointless to attempt to say which is number one; all are serious. A properly designed electric installation recognizes and protects against all hazards. Unfortunately, no single type of electric-equipment enclosure is best in all respects. General-purpose type equipment, for instance, is adaptable to the finest in relaying and automatic controls and, thus, is the best insurance against power failure. But when considered from the point of view of fire and explosion hazards, general-purpose equipment is totally inadequate. On the other hand, explosionproof equipment, correctly designed and manufactured, properly installed, and carefully maintained, is the best protection against the dangers of fire and explosion. But explosionproof equipment does not have the protection against shock provided by the safety interlocks, the isolating barriers, the drawout features, and the working clearances found in general-purpose equipment. General-purpose equipment is inexpensive, whereas explosionproof equipment is expensive. To use explosionproof equipment where it is not necessary is spendthrift; to use general-purpose equipment where it is not safe is foolhardy. These are only a few of the advantages and limitations of each type of equipment. The safest installation takes full advantage of the best features of each type. However, this approach is possible only if the degree and extent of the areas of hazard are clearly defined.

AREA OF HAZARDS

IT IS ELEMENTARY that the safest thing to do would be the elimination of electric installations in hazardous areas. This, of course, is not practical. The next best thing is to limit electric installations in hazardous areas only to those items that cannot reasonably be made elsewhere. This can be practiced when the areas of hazard are defined accurately.

There are many practical reasons why electric installations, even though the construction is fully explosionproof, should be held to the minimum in hazardous areas. From personal observation of plants on an industry-wide basis, countless examples illustrating the difficulties of adequately policing extensive electric installations in hazardous areas can be found. Such things as explosionproof enclosures, that are in service with the cover bolts loose or missing or sometimes even with the cover gone altogether, are not unusual. Everyone is familiar with the adaptor or cheater that most mechanics carry to convert explosionproof receptacles to the ordinary garden-variety household type.

Text of a conference paper presented at the AIEE National Electrical Conference of the Petroleum Conference, Houston, Tex., September 12–14, 1955, and recommended for publication by the AIEE Committee on Petroleum Industry.

L. M. Goldsmith is with The Atlantic Refining Company, Inc., Philadelphia, Pa.

The author, chairman of the American Petroleum Institute (API) Subcommittee on Electrical Equipment, wishes to acknowledge the contributions of the API Refinery Subcommittee on Electrical Equipment, consisting of the following members: E. J. Nopper, Sun Oil Company; G. A. Hauske, Pure Oil Company; W. H. Dickinson, Esso Research and Engineering Company; J. C. Howard, Standard Oil Company of Indiana; R. P. Howell, Standard Oil Company of California; E. R. Hoyle, Sinclair Refining Company; E. W. Kleinpeter, Ethyl Corporation; T. R. Shaw, Phillips Petroleum Company; F. C. Somers, The Atlantic Refining Company; H. M. Stewart, Humble Oil and Refining Company; and K. N. Thompson, Socony Mobile Oil Company.

This is common during refinery unit shutdowns and in many cases allowed to remain after the unit goes on stream again. The use of such devices is widespread. In fact, this questionable art has developed to the point that cheaters with as many as three outlets on the general-purpose end are now in circulation. Pressure ventilated switch rooms have their own special brand of problems. Open doors and windows, inoperative blowers, and closed dampers are the prime offenders. Changes or additions to the plant that jeopardize the "safe" source of the air for ventilation are another headache. A close inspection of almost any refinery would probably uncover similar examples. Such things point up the fact that no matter how carefully an installation is designed and constructed, the safety features are easily nullified. Therefore, the safest approach is to minimize electric installations in hazardous areas.

It is astounding how much confusion, disagreement, and inconsistency have surrounded the problem of classifying locations as Division *1* or *2*, or as nonhazardous. Equal chaos prevails on determining the extent of a hazardous area. Opinions have ranged from the "everything within the fence" philosophy to the 25-foot rule. Disagreement and inconsistency between different organizations or different geographic areas are at least understandable. Inconsistencies within the same organization resulting in contradiction on the same installation are beyond explanation—yet common. Everyone has seen a lineup of explosionproof switchgear within a few feet of a general-purpose switchgear assembly. Obviously one or the other is a misapplication. Either a lot of money was wasted on explosionproof switchgear or a very unsafe installation of general-purpose switchgear was made. Similarly, many have seen identical explosionproof air circuit breakers installed side by side with one breaker equipped with conduit seals while the other one has no seals at all. Which one is correct? Was money wasted on explosionproof breakers, or was a hazard created by omitting the seals on the one breaker?

START OF PROJECT

Because of the importance of accurate and reliable classification of hazardous areas, both from the standpoint of safety and first cost of installations, and because of the obvious lack of any recognized sound basis for making such classifications, the American Petroleum Institute (API) became interested in the problem. In 1951, the API's Subcommittee on Electrical Equipment was asked to undertake a project intended to develop a sound basis and understandable procedure for determining the existence, classification, and extent of hazardous areas in petroleum refineries. This work culminated early in 1955 with the publication of API Recommended Practice *RP-500*, Classification of Refinery Areas for Installation of Electrical Equipment. It is believed that the recommendations contained in *RP-500* will, if applied with intelligence, lead to accurate and consistent classification of the degree and extent of hazards. This, in turn, will provide a reasonable and consistent basis for selecting the safest equipment and installing it in the safest location. For perhaps the first time, the industry will get the maximum in safety for its effort and money.

The first step in developing *RP-500* consisted of a survey of the practices of the refining companies participating in API. At that time, it was hoped that such a survey would indicate that a substantial majority of the industry was following identical practices. The fact that a majority followed a particular practice would be taken as evidence of its soundness and, thus, the job could be reduced to one of determining and formalizing the practice of the majority. The first survey indicated total disagreement. A second survey was made, but the results were the same. About this time, it became obvious that the only thing to do would be to start from the bare fundamentals in an attempt to reason our way to the correct answer, of course tempering the reasoning with the judgment and experience of the committee members. Considered in great detail were such things as: the conditions necessary to create a hazard; the sources of hazard, including types, sizes, and flash points; and the factors affecting the extent of a hazardous area, such as ventilation, quantity of inflammable material released, air currents, density of inflammable material, etc. It soon became obvious that to pinpoint the factors entering into each installation would result in an unwieldy and completely unworkable solution. The simple and straightforward solution was thought to be of utmost importance. In other words, unless the recommendations could be understood by the average electrical man and used with a reasonable amount of time and effort, the recommendations would be of little value. Accordingly, it was decided that a broad approach was the proper one, and that the recommendations should be made sufficiently conservative so that variations in small details would not alter the soundness of the solutions.

At the outset, it should be realized that *RP-500* is not a legal document, merely a recommended practice. Also, it is a series of recommendations that are felt to be adequate for typical or average cases. It is intended that sound judgment accompany the use of this material; where, in the opinion of the engineer, particular conditions are better or worse than average, the recommendations of *RP-500* should be modified appropriately. *RP-500* is not an attempt to rewrite or otherwise supersede the National Electrical Code (NEC); rather it is intended to serve as a supplement. The NEC is quite specific on the type of equipment to be used in hazardous areas. Once the degree and extent of hazard have been determined, there is little difficulty in understanding what the requirements are for equipment. The real problem is determining the existence, degree, and extent of a hazardous area. The NEC has established certain criteria for making this determination, and *RP-500* attempts to apply these criteria to typical oil refinery installations.

AREAS DEFINED

Hazardous areas are defined in Article 500 of the NEC; two areas directly and a third indirectly cited. These areas are:

Division 1 Areas. The criterion for these locations is that they may be hazardous under normal conditions.

Division 2 Areas. The criterion for these locations is that they may become hazardous only under abnormal conditions, such as the failure of a gasket, etc.

Nonhazardous Areas. These are locations that cannot be classified as Division *1* or *2*.

The terminology and criteria of the NEC are used in the definitions developed in *RP-500*.

Three conditions must be satisfied in order to have a fire or explosion. The conditions are: (1) A flammable material must be present; (2) the flammable material must be present in the proper proportions to ignite; and (3) a source of ignition must be present.

The first thing that must be done is to decide what is a flammable material. *RP-500* proposed that materials be judged flammable if they meet the following conditions: (1) Any material being handled, processed, or stored at a temperature above its flash point; and (2) All materials with a flash point less than 150 F. The basis for the first rule is obvious; the second rule is based on conservative judgment backed by the combined experience of the sponsors.

Whether a flammable material can be present in proper proportions to ignite leads to endless complications. This report assumes that if a flammable material is present, it will be in a state to ignite. This assumes the worst and, thus, is conservative. Generally, if flammable materials are handled in an area, there is a possibility of their getting into the air either normally or as the result of some abnormal occurrence. At this point, "abnormal" must be defined. Abnormal is here used in a limited sense; intended to cover those things that can go wrong short of a major catastrophe. It is generally recognized that it is not possible to protect against such extremes. Thus, except for a few special cases which are spelled out in *RP-500*, any location in which a flammable material is handled, processed, or stored is hazardous.

As stated previously, the NEC criterion for Division *1* is whether the location can be hazardous under normal conditions. For Division *2* the criterion is whether the location can be hazardous only under abnormal conditions. "Normal" does not necessarily mean the situation that prevails when everything is working properly. For instance, an operation might be so sensitive to control that frequent operation of the relief valves occurs. This would be considered "normal" and if the valves might release flammable material to the atmosphere, the location would be classed as Division *1*. On the other hand, if the operation of the relief valves occurred infrequently under unusual conditions, it would not be considered "normal." Similarly, there are cases where frequent maintenance and repair are necessary. This would be viewed as "normal" and if flammable material might be released as a result of the maintenance, the location would be Division *1*. However, if repairs were not usually required between turnarounds, the need to do repair work would not be considered "normal."

The hardest part is to arrive at a basis for determining the extent of a hazardous area. Perhaps a good beginning is to start with the fact that hydrocarbons are generally heavier than air. Their behavior in air is somewhat like a liquid in that they tend to sink to the ground, billow along the ground, and seek and settle in low spots. This liquid-like behavior leads to several conclusions: (1) In the absence of walls, enclosures, or other barriers, and in the absence of air currents or similar disturbing forces, it must be assumed that a vapor will travel equally in all directions; thus, if the source of hazard were a single point, the area covered by the vapor would be a circle; (2) The locations most likely to be hazardous are below grade; those at grade are next most likely; as the height above increases, the likelihood of hazard decreases; (3) Safe distances or clearances in the vertical direction are much less than in the horizontal direction.

"TWILIGHT" ZONE

ANOTHER concept that must be understood is that there is always a "twilight" zone between a Division *1* (normally hazardous) location and a nonhazardous location. Obviously, one side of an imaginary line cannot be normally hazardous and the opposite side never be hazardous. There has to be a zone that could be hazardous under abnormal conditions. These conditions might be unfavorable air currents, an abnormally large release of flammable material, etc.

It is quite easy to acquire an exaggerated conception of the extensiveness of Division *1* locations. The probable reason for this misconception is that it is very hard to refrain from thinking in terms of what could happen if a major piece of equipment exploded. It takes constant mental discipline to think in terms of what can happen under normal conditions. Surely the failure of a major item of equipment is not a normal condition; such an occurrence is abnormal in every sense of the word. This does not mean the abnormal is not a consideration in the over-all picture. That is the significance of Division *2*—the twilight zone that always exists between a source of hazard and a nonhazardous area.

Correctly evaluated, a refinery installation in a freely ventilated area will be found to be a multiplicity of Division *1* locations of extremely limited extent. What releases flammable materials under normal conditions? Probably most numerous of offenders is the packing gland. *RP-500* concludes that the Division *1* locations may exist around packing glands, that in freely ventilated areas the extent of the hazard is so small it may be ignored. Glands located where the free dispersion of vapors is restricted are different. Here there is the chance of the flammable material accumulating, and the whole area of restricted ventilation should be classified Division *1*.

RECOMMENDATIONS

CLEARANCES recommended in *RP-500* are presented graphically. These recommendations have been based on a careful weighing of all pertinent factors in the light of the available experimental data and the experience of a large segment of the oil refining industry.

Figs. 1 and 2 cover refinery process areas with unrestricted ventilation where flammable materials are handled only in closed systems. It will be seen that the ex-

tent of Division *1* locations is negligible for the above-grade locations. All areas below grade are considered Division *1*. The extent of Division *2* locations may be determined by applying the clearances given in Fig. 1 and Fig. 2.

Fig. 3 applies to refinery process areas with restricted ventilation. Note that, in this area, the entire area of restricted ventilation is classified Division *1*. A buffer zone or area classified Division *2* surrounds the Division *1* area. Horizontal and vertical dimensions are given for determining the extent of the Division *2* area.

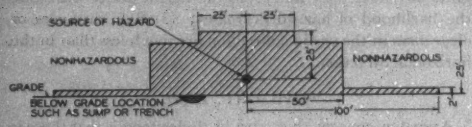


Fig. 1. Freely ventilated process area; source of hazard located near grade

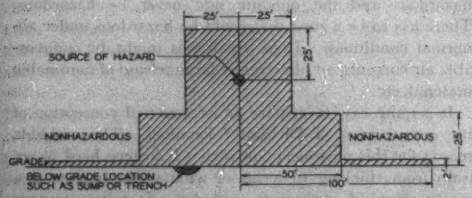


Fig. 2. Freely ventilated process area; source of hazard located above grade

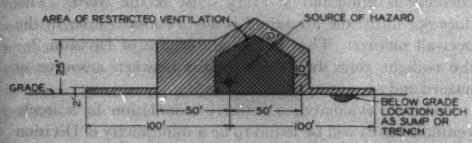


Fig. 3. Process area with restricted ventilation; apply above dimensions or 10 feet beyond perimeter of building, whichever is greater

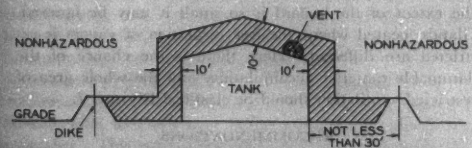
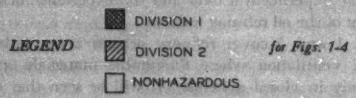


Fig. 4. Tank farm; for floating roof tanks, area above tank roof and within the shell is classified Division 1



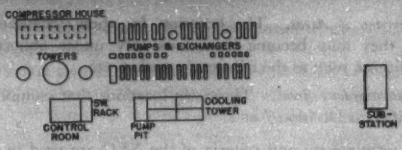


Fig. 5. Step 1—Affirmative answer to any of the following indicates the existence of a hazard: Is the presence of flammable liquids or vapors having flash points less than 70 F likely? (No); Are any flammable liquids or vapors having flash points under 200 F likely to be handled, processed, or stored at temperatures above their flash points? (Yes)

Fig. 4 applies to storage tanks and indicates the only Division *1* areas are the interior vapor space of the tank and the exterior area in the immediate vicinity of the vents. Clearances both horizontal and vertical are given for determining the extent of the Division *2* area which is indicated to surround the tanks. Note the warning regarding high filling rates or blending operations involving liquids with flash points of 70 F or below.

NEC Article *5125* provides a specific classification for loading racks and gives clearance distances for determining the dimensions of the classified area. Thus, *RP-500* recommends Article *5125* be used when dealing with loading racks.

RP-500 contains a 4-step procedure for classifying refinery locations. The steps, in the order in which they are taken, are for the purpose of establishing the existence of a potential hazard, for determining the degree of potential hazard, for determining the extent of hazardous area, and for determining the NEC grouping of the atmospheric mixture. The first two steps consist of a series of questions; the third step concerns the application of Figs. 1 through 4; and the fourth step involves checking the flammable material in question against the NEC grouping.

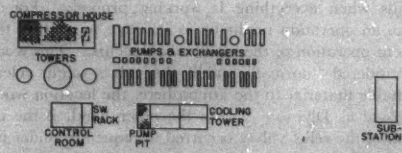


Fig. 6. Step 2—Affirmative answer to any of the following indicates existence of Division 1 location: Is a hazardous gas or vapor concentration likely to exist in the air under normal operating conditions? (No); Would a flammable atmospheric concentration occur often because of maintenance, repairs, or leakage? (No); Would a failure of equipment be likely to cause a simultaneous electrical system failure? (No); Is the area not freely ventilated and one in which flammable materials are handled in other than tight equipment or containers? (Yes, compressor house); Is the area below grade? (Yes, pump pit)

By way of illustrating the use of this procedure, consider Fig. 5, which is a typical refinery unit. The lower portion of the figure contains the questions making up Step *1*. Inasmuch as the answers are affirmative, a potential hazard must exist. Fig. 6 is the same block plan as Fig. 5 except the questions making up the portion of Step *2* intended to test for Division *1* are shown. This operation indicates that Division *1* hazards exist in the compressor-house and cooling-tower pump pit. These areas are double crosshatched to indicate Division *1*. Fig. 7 covers the remaining operation of Step *2*, which is designed to test for Division *2*. Based on the answers to these questions, it is determined that the outdoor process area should be classified Division *2* and these areas are single crosshatched accordingly. Note that the extent of the Division *1* and Division *2* areas is indefinite at this stage as indicated by the irregular perimeter of the crosshatching. Step *3* is used to establish the extent of the classified areas, and Fig. 8 illustrates this operation. As instructed in Step *3*, the clearances given in Figs. 1, 2, and 3 have been applied with the result that the extent of the Division *2* areas is as indicated by the single crosshatching, while the double crosshatching indicates the extent of the Division *1* areas. Note that the substation, which is made up of general-purpose equipment, is located outside the limits of the Division *2* areas, while the switch rack, which is made up of explosion-proof equipment, is located next to the control house, which is well within a Division *2* area. Fig. 9 is a continuation for purposes of illustrating Step *4*. Since the flammable materials in this process which might create a hazard are hydrocarbons commonly encountered in refineries, the proper NEC atmospheric grouping is Group *D*. Thus, by these four steps, the area has been completely classified as to degree, extent, and group.

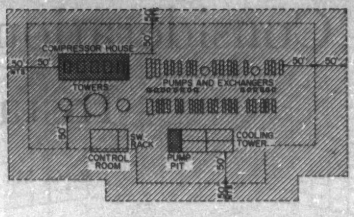


Fig. 8. Step 3—Determination of the extent of the hazardous areas: The extent of a classified location is determined by applying the recommended distances given in Figs. 1–4. Within an area extending 50 feet from all equipment the vertical extent of the Division 2 location is 25 feet above grade or equipment whichever is higher; within the outer 50-foot band the vertical extent is 2 feet above grade

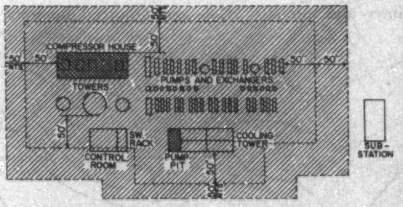


Fig. 9. Step 4—Determination of proper National Electric Code (NEC) grouping of atmospheric mixtures: As only hydrocarbons commonly encountered in refineries would be present, the proper NEC atmospheric grouping is Group *D*

CONCLUSION

A SOUND AND PRACTICAL BASIS for accurately and consistently classifying hazardous areas in refineries is provided in *RP-500*. However, this is by no means the end of the road. It is expected that *RP-500* will require revision periodically as experience is acquired in its use. Another problem that must always be considered, regardless of how proficient one becomes in classifying areas, is that of making sure an installation is put in as designed. Designs must be executed exactly, and construction supervisors and inspectors must be given a better understanding of why this is important.

Another phase that needs attention is the lack of equipment designed for Division *2* locations, and the applications of presently available materials and equipment not now accepted for Division *2* installations. An example of this is found in wiring methods. One of the greatest hazards in the use of conduits is the passage of gas through the conduit from a hazardous to a nonhazardous area, thereby creating a hazard in a supposedly safe location, and affording a means for a flash to be transmitted to the hazardous area. Even though seals are used, their effectiveness is often questionable. The use of mineral-insulated and armoured cable, though not Underwriters approved for hazardous-area wiring, would eliminate this hazard. A suggested solution to these problems would be a project undertaken in the interest of promoting both safety and economy in electric installations.

Fig. 7. Step 2—Affirmative answer to any of the following indicates existence of Division 2 location: Is the location freely ventilated, and are flammable materials handled in closed systems (other than tight piping systems) from which escape would be abnormal, or stored in other than closed containers? (Yes, except compressor house); Is the area next to a Division 1 area, or can vapor be communicated to it through trenches, ducts, etc.? (Yes); If positive mechanical ventilation is used, in event of its failure or abnormal operation, could a hazardous vapor concentration build up? (No)

Considerations of Microwave Installations

R. G. McLAUGHLIN

The principles of microwave propagation are explained by means of a description of the steps and considerations necessary in the setting up of a typical installation.

MICROWAVE EQUIPMENT has won wide acceptance as a reliable, economical means of relaying television and audio intelligence. Successful applications include studio-to-transmitter (STL), remote pick-up, inter- and intra-city relay, and industrial monitors.

When success is not achieved, it is usually not the equipment but the installation that is at fault. That is, the equipment is set up without regard for the principles of microwave propagation as if it provided a magic beam that could overcome all obstacles.

It is sometimes possible to achieve successful operation by trial and error, but only with the added time and expense of repeated relocation. A properly planned installation operates effectively after the initial installation and continues to provide reliable service.

Successful installation presupposes some knowledge of the principles of microwave propagation. Each set-up requires a careful survey of the proposed site and a specific analysis of the topographical and meteorological factors involved. These requirements are not so formidable as they sound, however, and it is the purpose of this article to present them in simple and practical form. The approach will be to take a typical relay problem and consider all its aspects.

A TYPICAL INSTALLATION

AN STL INSTALLATION may be planned, for example, from point *A* to point *D*, as shown in Fig. 1, a total distance of about 60 miles over rugged terrain. Point *B* suggests itself as one relay point, since it has sufficient elevation, is readily accessible by roads, and has the necessary facilities for communication and alignment. Point *C* likewise has power and communication facilities and also has a 100-foot water tower available for lease should additional height be required. Point *C'* also appears to have all the necessary requirements: power, communication, elevation, and an FM tower for possible lease. At terminating point *D*, the television transmitter

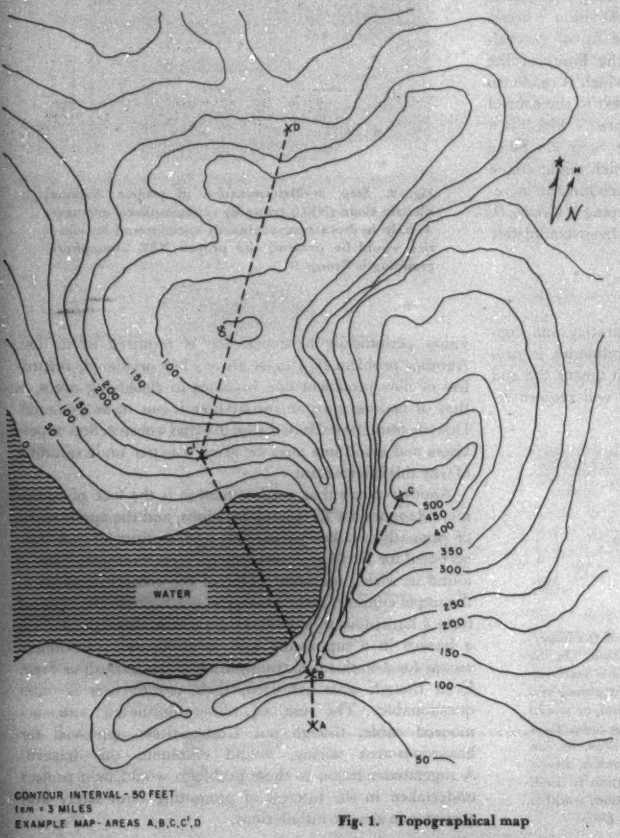


Fig. 1. Topographical map

Revised text of a conference paper presented at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955, at a session sponsored by the AIEE Committee on Television and Aural Broadcasting Systems.

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tower is available to mount passive reflectors if additional microwave clearance is required.

With these points in mind we are contemplating a three-hop installation: *A* to *B*, *B* to *C'* or *C*, and *C* or *C'* to *D*. Let us now analyze each hop in turn.

First, *A* and *B*, as Fig. 2 shows, are only 5 miles apart. Normally it would seem that if we were able to view point *B* from *A* and vice versa, the line-of-sight requirement would be fulfilled. Nevertheless, a profile plot of the contour area should be examined, since this is the only way to get an accurate picture of actual clearance above the terrain. The adequacy of the existing clearance can now be determined. (The importance of adequate clearance cannot be fully understood without reviewing the characteristics of microwave reflection.)

Referring now to Fig. 3, assume that Y_1, Y_2, and Y_3 are points at which the energy could be reflected when in transit from *X* to *Z*, and that the transmitted energy following path *X-Y-Z* arrives at *Z* in time *T*. Then:

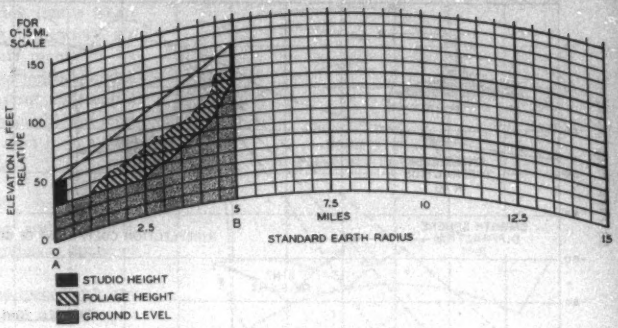

Fig. 2. Contour profile chart, *A* to *B*

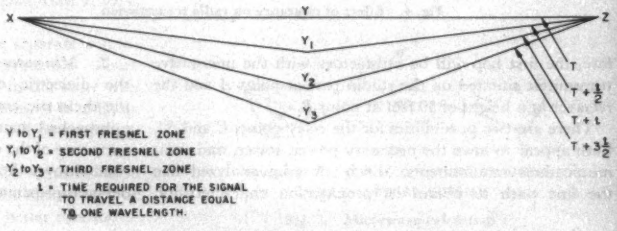

Fig. 3. Fresnel zones for microwave systems

1. If the transmitted signal following path *X-Y*$_1$-*Z* arrives at point *Z* in time *T* (plus the time necessary for the signal to travel a distance equal to one half its wavelength), then Y_1 is considered the limit of the first Fresnel zone.

2. If the transmitted signal following path *X-Y*$_2$-*Z* arrives at point *Z* in time *T* (plus the time necessary for the signal to travel a distance equal to one full wavelength), then Y_2 is considered the limit of the second Fresnel zone.

3. If the transmitted signal following path *X-Y*$_3$-*Z* arrives at point *Z* in time *T* (plus the time necessary for the signal to travel a distance equal to three halves its wavelength), then Y_3 is considered the limit of the third Fresnel zone; etc.

Now for very small angles of reflection, there is a 180-degree phase shift in the signal. Assuming that distances of *Y-Y*$_1$, *Y-Y*$_2$, and *Y-Y*$_3$ are small as compared with that of *X-Z*, then:

1. The signal reflected at the limit of the first Fresnel zone (*X-Y*$_1$-*Z*) arrives at the receiver in phase and will tend to aid the directly received signal (*X-Y-Z*).

2. The signal reflected at the limit of the second Fresnel zone (*X-Y*$_2$-*Z*) arrives at the receiver 180 degrees out of phase and will tend to cancel the directly received signal (*X-Y-Z*).

3. The signal reflected at the limit of the third Fresnel zone (*X-Y*$_3$-*Z*) arrives at the receiver in phase and will tend to aid the directly received signal (*X-Y-Z*); etc.

A plot of the loss or gain of the received signal strength as regards Fresnel zone is shown in Fig. 4, which appeared in *Telephony*, September 12, 1953, courtesy of R. D. Campbell of The American Telephone and Telegraph Company. It is easily seen that the condition between 0.5 and 1.5 of the first Fresnel zone is desirable.

At this point, due consideration must be given both to adequate clearance and to tower costs. A reasonable compromise between these two considerations is that of 6/10 first Fresnel zone radius clearance of all obstructions.

There is a point where the 6/10 Fresnel zone is not the predominant clearance factor. Beyond this point, the amount of clearance required for atmospheric bending of microwave rays must be taken into consideration. This will be explained further in the discussion of the second hop.

TOPOGRAPHICAL CONSIDERATIONS

TREE AND BUILDING HEIGHTS are not usually shown on topographic maps and must be determined by personal reconnaissance of the area in question. Reconnaissance for this first hop shows a thick growth of 30-foot trees, as sketched in Fig. 2, and the profile indicates an adequate clearance of 30 feet at the midpoint, provided the receiver is elevated at point *B* to a height of 30 feet above the ground. This elevation will allow for 10 feet of tree growth plus adequate additional clearance of 20 feet. (Over virgin forests no allowance need be made for growth.) There-

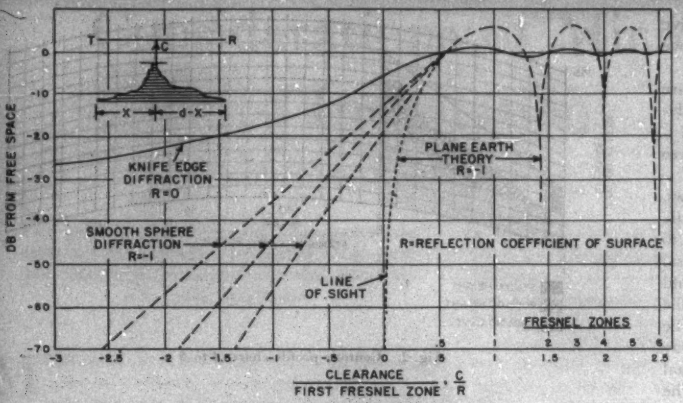

Fig. 4. Effect of clearance on radio transmission

fore, the first hop will be satisfactory with the microwave transmitter situated on the studio roof at point *A* and the receiver at a height of 30 feet at point *B*.

There are two possibilities for the relay points *C* and *C'*. Both appear to have the necessary power, tower, and communications requirements. Each must be analyzed like the first path to obtain its propagation characteristics.

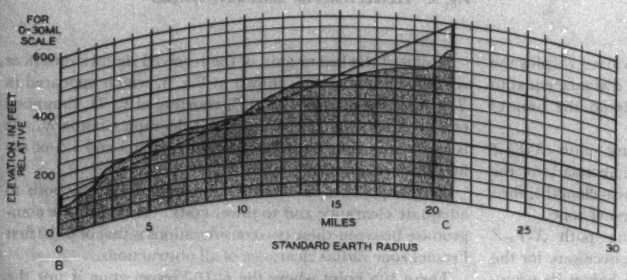

Fig. 5. Contour profile chart, *B* to *C*

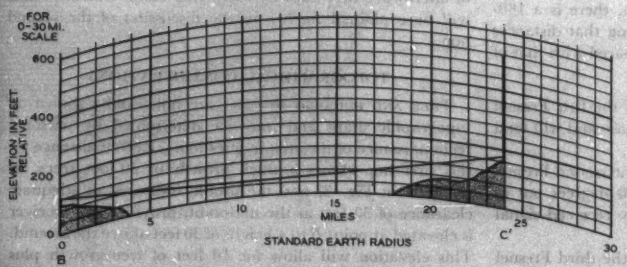

Fig. 6. Contour profile chart, *B* to *C'*

From Fig. 5, a profile chart of the area between points *B* and *C*, it is evident that the existing towers are not quite high enough to give adequate clearance. A survey of path *B-C'*, as shown in Fig. 6, shows that this path is more favorable as to clearance but introduces another problem—the severe and unpredictable fading that may occur in overwater hops.

FADING

OVER-WATER FADING may be due to any of the following causes:

1. *Reflections*, as was pointed out in the discussion of Fresnel zone clearance.

2. *Microwave bending*, resulting from the difference in the dielectric constant of the atmosphere. Normally the dielectric constant of the air increases as the earth is approached, causing a bending that tends to follow the curvature of the earth, as shown in Fig. 7-1. This bending results in over-the-horizon transmission, the distance spanned being approximately the same as that of a direct (unbent) microwave path plotted on a 4/3 earth radius profile chart. Sometimes, however, this change in dielectric constant with elevation is greater than normal so that the beam is bent more sharply toward the earth, and in such cases, reflections (as shown in Fig. 7-2) are possible. At other times, meteorological conditions existing over various stretches of earth and more of ten over water are such that the normal dielectric constant distribution in the atmosphere is inverted so that the beam is bent upward (away from the earth), as shown in Fig. 7-3. In this sketch, transmitted ray *A* (which normally would follow the straight path shown by the dotted line *B*) is being bent upward so as to miss the intended receiver point. Transmitted ray *C* (which normally would follow the dotted line *D*) is also bent and would follow path *C* if there were sufficient topographic clearance. To ensure proper clearance for upward bending in most cases, we should use transmitter and receiver heights which will accommodate grazing clearance when plotted on 2/3 earth radius profile paper (Fig. 8).

3. *Ducting*, a peculiar phenomenon that results when there is no solar heating, no turbulence and, therefore, air stratification. Each separate layer of air maintains its specific moisture content and density characteristics, and a sandwiched layer (if the dielectric constant differential between it and those juxtaposed is great enough) will tend to capture the microwave signal and conduct it on a false path so as to miss the receiving antenna.

DIVERSITY TECHNIQUES

FADING resulting from ducting, bending, and multipath reflection effects can be overcome by employing space or frequency diversity techniques.

For space diversity, two receivers are so spaced that the first will receive the reflected or bent ray at a 180-degree phase lead with respect to the second. Thus, when the net received signal of the first receiver is at a minimum, the net received signal of the second is at a maximum. Consequently, there is always sufficient signal from at least one receiver.

For frequency diversity, two or more separate microwave systems are operated on different frequencies. Since no two microwave frequencies will react in the same way to a particular set of atmospheric conditions, it is unlikely that more than one frequency at a time will be subject to fading.

Diversity techniques are not ordinarily required in a well-planned installation; they are extreme measures to be used only over very difficult terrain. A better solution in the present case will be to use a 1-watt microwave transmitter rather than the 100-milliwatt type, as the higher power will give approximately 10 db more fading margin. We can also employ 6-foot paraboloids for more gain; however, this will reduce the beam width to approximately 1.7 degrees.

Turning now to the third hop (*C'* to *D*), the profile of this 36-mile path can be plotted (Fig. 9). It is found that for adequate clearance, heights of 250 feet at the transmitter and 150 feet at the receiver are required. To mount the microwave units at these heights on the towers would be quite impractical from the maintenance viewpoint and would introduce an unfavorable signal-to-noise ratio, commonly encountered in coaxial lines of this length. A solution is to install passive reflectors which can provide an effective signal gain. The gain of power is dependent upon (1) microwave frequency, (2) distances between the reflector and the paraboloid, (3) diameter of the paraboloid, and (4) size of the passive reflector.[1]

Using a paraboloid-to-reflector distance of 250 feet with a 4-foot paraboloid at a frequency of 7,000 mc, the gain figures for various sizes of passive reflectors will be approximately as follows:

Reflector Size (feet)	Gain (db)
10 x 15	3.5
8 x 12	1.0
6 x 8	3.0 *loss*

Using a paraboloid-to-reflector distance of 150 feet with

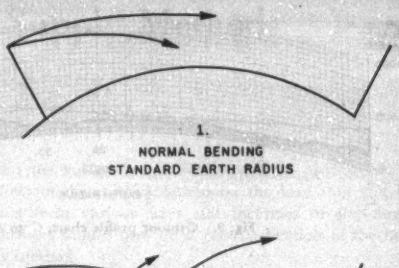

Fig. 7. Microwave refraction

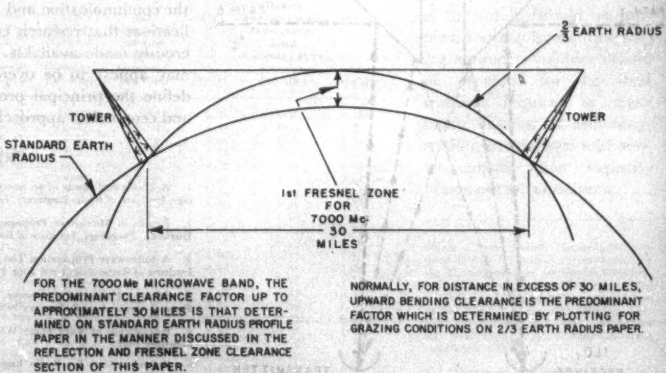
4/3 EARTH RADIUS
TOWER
TOWER
STANDARD EARTH RADIUS
1st FRESNEL ZONE FOR 7000 Mc
30 MILES
FOR THE 7000 Mc MICROWAVE BAND, THE PREDOMINANT CLEARANCE FACTOR UP TO APPROXIMATELY 30 MILES IS THAT DETERMINED ON STANDARD EARTH RADIUS PROFILE PAPER IN THE MANNER DISCUSSED IN THE REFLECTION AND FRESNEL ZONE CLEARANCE SECTION OF THIS PAPER.
NORMALLY, FOR DISTANCE IN EXCESS OF 30 MILES, UPWARD BENDING CLEARANCE IS THE PREDOMINANT FACTOR WHICH IS DETERMINED BY PLOTTING FOR GRAZING CONDITIONS ON 2/3 EARTH RADIUS PAPER.

Fig. 8. Microwave clearance problem

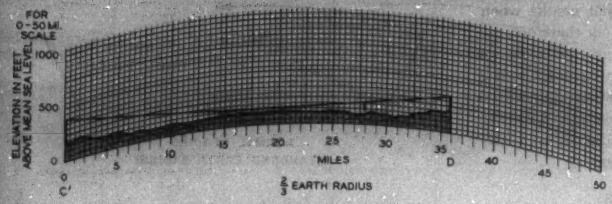

Fig. 9. Contour profile chart, C' to D

a 4-foot paraboloid and a frequency of 7,000 mc, the gain figures become:

Reflector Size (feet)	Gain (db)
10 x 15	2.5
8 x 12	2.5
6 x 8	0.0

It is now necessary to weigh signal gain against reflector cost. A 10- by 15-foot passive reflector costs about $500 more than an 8- by 12-foot one and an 8- by 12-foot reflector costs about $150 more than a 6- by 8-foot one. Since this is a three-hop installation, the additional gain warrants the added expenditure, and we therefore plan to install the 10- by 15-foot refector at the transmitter location C' and the 8- by 12-foot one at the receiver location D.

To ensure reliable operation of passive reflectors, the supporting towers must meet rigid specifications for twist and sway. Given these specifications and the size and height of the passive reflector, the tower contractor will be able to provide a structure of the required strength and rigidity.

SIGNAL-TO-NOISE RATIO

THE NET SIGNAL-TO-NOISE RATIO of the entire system depends upon the ratio of each hop and will always be lower than the lowest signal-to-noise reading. For the first hop of 5 miles, the calculated signal-to-noise ratio, using 100-mw microwave equipment with 4-foot paraboloids in the 7,000-mc band, will be approximately 48 db (rms to rms).

The second hop of 24 miles, using 1-watt equipment with 4-foot paraboloids in the 7,000-mc band, will yield a signal-to-noise ratio of approximately 44 db.

The third hop of 36 miles, using 1-watt microwave equipment with 4-foot paraboloids in the 7,000-mc megacycle band, a 10- by 15-foot passive reflector at 250 feet, and an 8- by 12-foot passive reflector at 150 feet will yield a signal-to-noise ratio of approximately 44 db. The net signal-to-noise ratio of the system is approximately 40 db. This will allow a fading margin of 15 db above the threshold signal-to-noise ratio.

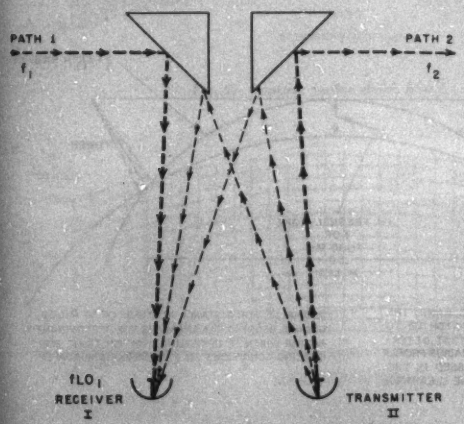

Fig. 10. Frequency interference problem

FREQUENCY INTERFERENCE

THE FINAL CONSIDERATION is frequency interference. Fig. 10 shows a typical microwave relay station. The signal power of system II being transmitted over path 2 is quite large as compared to that being received by system I over path 1, so that any signal that is reflected or spilled over from system II to system I is significant. Should the difference of radio frequency f_2 and that of the local oscillator LO_1, or the various harmonics thereof, fall within the intermediate-frequency bandpass of system I, interference would result. Consequently, before requesting a frequency allocation from the Federal Communications Commission, it is advisable to investigate interference possibilities not only within the system, but also between it and other microwave and radar systems in the area.

We have now considered most of the problems which the user of microwave equipment must face. Available to assist in their solution are the application engineers of the equipment manufacturers, the professional consultants in the communication and television field, and the many publications that research engineering personnel have so generously made available. The foregoing discussion, which may appear to be over-simplified, is merely intended to define the principal problems and indicate a satisfactory and economical approach to their solution.

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General Study of Area Supply Methods

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ELECTRIC POWER is usually delivered to the distributed loads of an area by superimposed voltage webs or networks. In general, the higher voltage webs are used to transmit power, whereas the lower voltage webs, which provide much denser area coverage, are used to distribute power. Connections are required between the webs, which consist of step-down transformers with the necessary switching and protective apparatus. There are three general methods of supplying the lower voltage networks:

1. *Radial networks.* Separate lower voltage networks, each of which is supplied from one step-down transformer location.

2. *Integrated networks.* Integrated lower voltage networks which are effectively one large network supplied from several step-down transformer locations.

3. *Radial networks with emergency cutovers.* Same as 1, except normally open ties are provided between the networks to make possible load transfers from one network to other networks under outage or emergency conditions.

The best supply method will result in the minimum overall cost. Such factors as service reliability; thermal and voltage conditions, both normal and emergency; short-circuit duties; and relaying and protection difficulties must be considered. Analysis of all of these factors in a theoretical study is impossible because of the vast number of variables involved.

However, experience has shown that one of the more costly elements in the supply system is the connections between the voltage webs. Consequently, an analysis of the effect of the supply method on the load that can be supplied from various sizes and locations of step-down transformers should provide a good indication of the best supply method.

The analysis was limited to the supply facilities for 26-kv subtransmission networks. However, it was made on a per-unit (pu) basis, thus making the results useful for all load sizes and voltage levels for which the basic assumptions apply.

For simplicity, the analysis was limited to cases involving two switching stations. A detailed investigation was made of the effect of bulk-supply-system and subtransmission-system conditions on switching-station transformer loading with integrated networks. This indicated that subtransmission conditions are usually more important than bulk-system conditions. The assumptions concerning subtransmission and bulk-system conditions that were used in comparing the supply methods were based on this investigation.

Both normal and emergency conditions were investigated for all three supply methods. For each case, the area capacity is the maximum load that can be supplied without exceeding normal ratings with all transformers in service; also without exceeding emergency ratings with one transformer out of service at a time.

A comparison of the three supply methods for various sizes and locations of transformers is given in Table I. The larger area capacities resulting from radial networks with emergency cutovers indicate that this probably is the best supply method in use.

Although more study is required, it appears that the heavy subtransmission loads of the future should be supplied radially by each switching station; facilities should be provided for the load transfers required to make maximum use of switching-station transformer and subtransmission line capacity under outage conditions.

Table I. Comparison of Area Capacities for the Three Supply Methods

Source A			Source B			(1)	(2)	(3)	(4) Radial Networks with Emergency Load Cutovers		(5)
Number of Transformers	Ratings,* Per Unit		Number of Transformers	Ratings,* Per Unit		Radial Network Area Capacity, Per Unit	Integrated Network Area Capacity, Per Unit	Δ (2)-(1)	Area Capacity, Per Unit	Δ (4)-(2)	
	Normal	Emergency		Normal	Emergency						
2	1.00	1.10	2	1.00	1.10	2.20	2.75	0.55	3.30	0.55	
2	1.00	1.10	2	1.55	1.75	2.85	3.39	0.54	3.95	0.56	
2	1.55	1.75	2	1.55	1.75	3.50	4.39	0.89	5.25	0.86	
3	1.00	1.10	2	1.00	1.10	3.30	3.58	0.28	4.40	0.82	
3	1.00	1.10	2	1.55	1.75	3.95	4.22	0.27	5.05	0.83	
3	1.55	1.75	2	1.00	1.10	4.60	5.06	0.46	5.70	0.64	
3	1.55	1.75	2	1.55	1.75	5.25	5.69	0.44	7.00	1.31	
3	1.00	1.10	3	1.00	1.10	4.40	4.96	0.56	5.50	0.54	
3	1.00	1.10	3	1.55	1.75	5.70	6.24	0.54	6.80	0.56	
3	1.55	1.75	3	1.55	1.75	7.00	7.91	0.91	8.75	0.84	
4	1.00	1.10	2	1.00	1.10	4.40	4.40	0	5.50	1.10	
4	1.00	1.10	2	1.55	1.75	5.05	5.03	−0.02	6.15	1.12	
4	1.55	1.75	2	1.00	1.10	6.35	6.39	0.04	7.45	1.06	
4	1.55	1.75	2	1.55	1.75	7.00	7.01	0.01	8.75	1.74	
4	1.00	1.10	3	1.00	1.10	5.50	5.87	0.37	6.60	0.73	
4	1.00	1.10	3	1.55	1.75	6.80	7.15	0.35	7.90	0.75	
4	1.55	1.75	3	1.00	1.10	7.45	8.08	0.63	8.55	0.47	
4	1.55	1.75	3	1.55	1.75	8.75	9.32	0.57	10.50	1.18	
4	1.00	1.10	4	1.00	1.10	6.60	7.15	0.55	7.70	0.55	
4	1.00	1.10	4	1.55	1.75	8.55	9.07	0.52	9.65	0.58	
4	1.55	1.75	4	1.55	1.75	10.50	11.38	0.88	12.25	0.87	

*Typical winter ratings of a 55-mva (nameplate) 132/26-kv transformer bank: Normal–100 mva; Emergency–110 mva.
Typical winter ratings of a 75-mva (nameplate) 132/26-kv transformer bank: Normal–155 mva; Emergency–175 mva.

Digest of paper 55-669, "General Study of Area Supply Methods," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Forecasting the Demand for Electricity

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SINCE FORECASTING OF LOADS is necessarily an inexact science, the advantages of using as many different series of data as may be available are evident. By this process, unreasonable extensions of one set of components may become evident when a parallel set of factors produces a different result. It has also been found very helpful to secure the benefit of group opinion. If the individuals in such a group are equally conversant with the facts, greater objectivity is achieved by discussion which produces agreement rather than mere averaging of preconceived opinions. Such a group should include representatives from operating, sales, and staff organizations.

In order to avoid being unduly influenced by recent occurrences, any forecast should be initiated by study of what may happen at some future date, such as a time 10 years away. When opinions have been crystallized on what is to be expected as of that date, the problem of extending historical data into the future has been greatly simplified.

The forecast should be based on studies of the various components which together will determine the demand for electricity. Residential sales will be dependent on population growth, increasing consumption per customer, new appliance developments, and similar factors. Forecasts of commercial sales will be closely related to residential forecasts and must take cognizance of the development of new suburban shopping areas.

The most important element in the forecast relates to industrial sales. This component may be studied by investigation of the long-term growth of industry, as shown in Fig. 1, and the growth in use of electricity per unit of growth in industry. Another approach depends upon studies of manufacturing workers and the use of electricity per worker, as shown in Fig. 2. Since most industrial customers are charged for their power on the basis of their kilowatt demand as well as on the basis of their energy consumption, it has been found useful to forecast the ratio of industrial kwhr sales to total industrial billed demand. This ratio has many of the elements of an index of industrial activity. Future industrial sales may also be studied on the basis of the expectations of specified groups of customers.

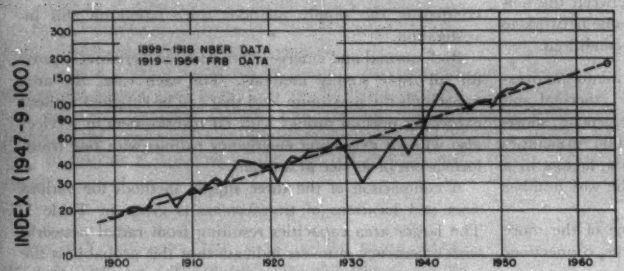

Fig. 1. Index of total manufactures

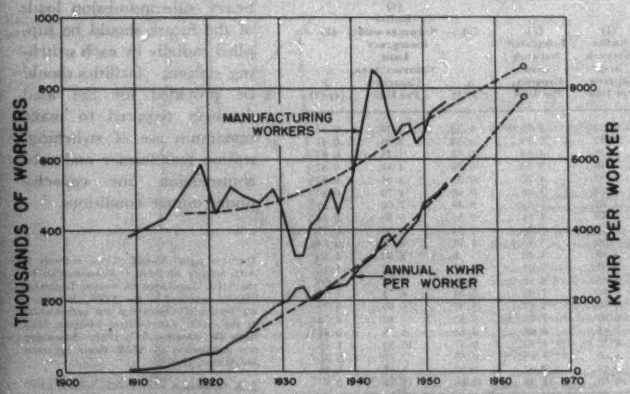

Fig. 2. Industrial sales per manufacturing worker

Forecasts of near-term use may best be established by estimating deviations from long-term trend. For residential and commercial sales such deviations are likely to be insignificant. For industrial sales, however, the immediate future will be heavily influenced by the business outlook.

When the sales forecast is completed, a forecast of output may be made and the kwhr figures converted to system-peak values. This may be done by use of load factors or by mathematical procedures. However, forecasts of sharp peaks or depressions are unlikely to be successful.

Digest of paper 55-530, recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Published in AIEE *Power Apparatus and Systems*, October 1955, pp. 993–1008.

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Future Application Needs of Carrier Pilot Relaying

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IT IS EXPECTED that the number of carrier pilot relay installations will follow approximately the same geometric growth rate as that exhibited by the electrical industry as a whole, that is, doubling every 10 or 11 years. If space in the frequency spectrum is to be available for these additional channels, as well as for other carrier applications, steps must be taken to avoid serious frequency congestion problems, which even now are being experienced in certain areas.

In view of the special nature of the carrier-relaying application, a number of practical steps can be taken to achieve maximum utilization of the carrier spectrum. One of these steps is the frequent repeating of the same frequency throughout the power transmission system. Usually, the same frequency can be reused on nonadjacent line sections. Another method of conserving frequency space is to use a receiver sensitivity that is adequate for the particular application, but is not greater than necessary. Increasing the sensitivity beyond the requirements of the application is equivalent to wasting the frequency spectrum, because increased spacing would be required between channels in order to avoid interference. The third and most important step in conserving space is the use of carrier equipment with characteristics which will permit the closest possible frequency spacing. The important equipment characteristics are selectivity, frequency stability, and reduction in harmonic output.

The new carrier-relaying equipment described here fulfills all of these basic requirements. In order to obtain the minimum possible spacing between carrier-relaying channels, the selectivity has been increased to the maximum value which can be employed without increasing the over-all relaying time. A typical selectivity curve, which applies for any channel frequency between 30 and 200 kc, is shown in Fig. 1. This increase in selectivity will enable two or three relay channels to occupy the space formerly occupied by one. Direct crystal control of the new transmitter is used for maximum frequency stability. A carefully designed filter is included in the transmitter output circuit to attenuate all harmonics that fall in the 30–200 kc band by more than 50 db, with even greater attenuation for harmonics above this band. The transmitter filter has sufficiently low insertion loss so that 10 watts of carrier power is delivered at the output terminal. Long-life and pre-aged tubes are conservatively used and will give the average life of one to two years normally expected for this type of service.

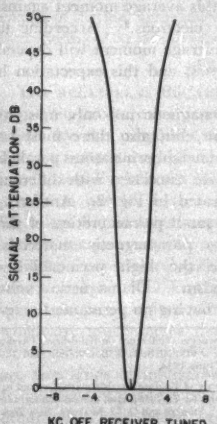

Fig. 1. Typical receiver filter selectivity characteristic

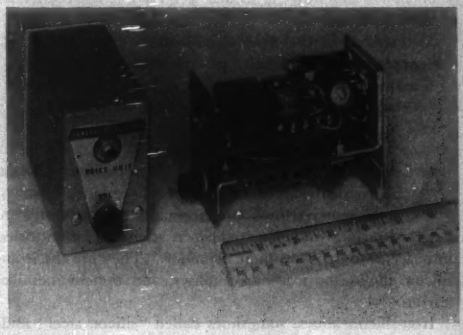

Fig. 2. Plug-in voice unit combining voice modulator and voice receiver, shown with cover removed

In past and present installations, channel bandwidth and spacing often have been governed by the requirement that test communication facilities be usable as a regular system communication channel, with the consequence that the bandwidth and spacing required are much wider than is dictated by the relaying function alone. A better arrangement is to group the relaying frequencies closely together, thus clearing a space in the spectrum for a high grade party-line telephone channel. Following this philosophy the new design makes provision for communication facilities for adjustment and maintenance only, and does not compromise the requirement of maximum selectivity and minimum permissible spacing. This is accomplished by the use of a completely transistorized portable plug-in voice unit consisting of a modulator and voice receiver, as shown in Fig. 2. The bandwidth of the relay receiver filter is much too narrow for communications; however, by using only a portion of this filter, sufficient bandwidth is obtained for voice communication without affecting the selectivity of the relay function. The control circuits are arranged to give full preference at all times to the protective relaying function.

Digest of paper 55-695, recommended by the AIEE Committees on Relays and Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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The Physics of Magnetic Materials

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Research in the field of solid-state physics has explained many of the phenomena of magnetic materials. These findings have led to many developments of practical engineering importance.

A LARGE PART of the physics of ferromagnetism can be learned from a discussion of three kinds of magnetic materials. These are used commercially in large quantities and are studied in scientific laboratories in order to understand their behavior. They are the iron-silicon alloys, the iron-nickel alloys, and the nonmetallic ferrites.

Iron-silicon alloys, sometimes called "silicon steel" and mainly used in power transformers and generators, are made in the United States to the extent of about 750,000 tons per year.[1] The annual value of the product to the consumer is now over $100 million. The dollar value of the magnetic losses that are dissipated each year in the cores of transformers and other electric equipment is larger than this, probably over $200 million.

The iron-nickel alloys are used mainly in the communications industries for transformers, coils, magnetic receivers, inductive loading, and permanent magnets. They cost much more per pound but are used in smaller quantities; the value of the annual product is now about $20 million in the United States.

The ferrites are relative newcomers as commercial materials, and have been manufactured in quantity only in the last several years. Already, the annual product has a value of approximately $10 million. Various applications have been made in communications equipment, especially in the radio–television industry.

ATOMIC STRUCTURE AND INTERACTION

THE ATOMIC STRUCTURE of a free atom of iron is shown in Fig. 1*A*, which indicates how the 26 extranuclear electrons are arranged in more or less well-defined shells. The origin of the magnetic moment of the atom is the spinning electron which is known to have a moment of 0.927×10^{-20} in cgs units, or 1 Bohr magneton. Although some magnetic moment results from the orbital motion of the electrons, this is not of prime importance in ferromagnetism.

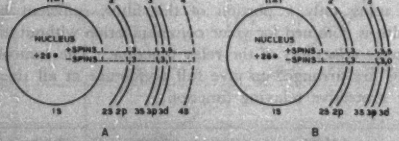

Fig. 1. Electron shells in: (A) free-iron atom, 26 electrons, 4 Bohr magnetons; (B) Fe^{+++} ion, 23 electrons, 5 Bohr magnetons. Unfilled 3d shell is responsible for magnet moment

The arrangement of electrons in the two inner shells is such that the spins cancel each other, leaving a net moment of zero. However, the third part of the third shell is not completely filled, and the spins are oriented so that they neutralize each other only partially. The atomic moment of atoms and ions of iron, cobalt, and nickel can be attributed to the unbalanced spins of their *3d* electrons.

In a free atom of iron the atomic moment should be the difference between the five *3d*+ spins and one *3d*− spin or 4 Bohr magnetons. In metallic iron the electron distribution is changed by the close proximity of neighboring atoms and, as a result, the net atomic moment is reduced to 2.2 Bohr magnetons.

In ferrites the iron is present mainly as the ferric ion Fe^{+++}. The electronic structure of this ion is shown in Fig. 1*B*, and from this one can see that its magnetic moment is 5 Bohr magnetons.

In ions such as Fe^{+++}, Fe^{++}, Ni^{++}, Mn^{++}, etc., which occur in nonmetallic compounds, the experimentally determined moment is usually close to that which can be deduced from the number of electrons in the ion. In the metals, however, the atomic moments are not so simply determined because of the uncertainties resulting from the conduction electrons. The average moment of the atoms in a pure metal or in an alloy can be determined by dividing the measured moment of a specimen by the number of atoms in it, and one can plot this average moment against the number of extranuclear electrons.[2] According to theory, one expects that the average moment will depend only on the number of electrons, and this expectation is reasonably well fulfilled.

If a material is to be ferromagnetic not only must its atoms have magnetic moments, but also there must be interatomic forces that maintain neighboring atoms parallel. The kinds of magnetism that are associated with different kinds of interaction are illustrated in Fig. 2. Antiferromagnetic materials have only small permeabilities, of the same order of magnitude as paramagnetic materials. Ferrimagnetic materials have the high permeabilities characteristic of ferromagnetism. Diamagnetic substances are composed of atoms having no permanent mag-

Revised text of an address given before the Carnegie Conference on Solid-State Physics in Engineering Education, sponsored by the National Science Foundation and the American Society of Engineering Education, June 1954.

Full text to appear as a chapter in "The Science of Engineering Materials," edited by J. E. Goldman, John Wiley and Sons, New York, N. Y., 1956; also, in modified form in "Recent Advances in Science," edited by M. H. Shamos and G. M. Murphy, New York University Press, New York, N. Y., 1956.

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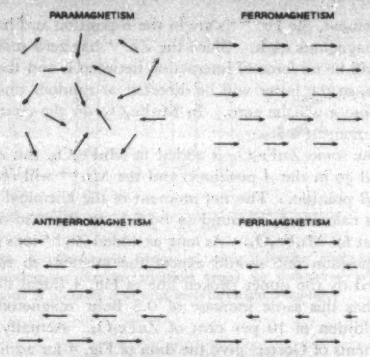

Fig. 2. Kinds of magnetism associated with various types of interatomic interaction: paramagnetism, weak interaction; ferromagnetism, "positive" interaction; antiferromagnetism, negative interaction; and ferrimagnetism, negative interaction between unequal moments

netic moments, but having small moments induced by the applied field and opposed to it in direction.

The interaction that exists between neighboring atoms and that orients their magnetic moments is quantum mechanical in origin. So far, its magnitude cannot be calculated precisely enough to be useful. If atoms are too close together their moments will tend to be held antiparallel; if far enough apart, they will be parallel. Slater[3] has shown that the ferromagnetic elements are those which have an unusually large ratio of interatomic distance to the diameter of the electron shell in which the magnetic moment (unbalanced spin) resides; the critical ratio between ferromagnetism and antiferromagnetism being at about 1.5. Our best measure of the energy of interaction is the Curie point on the Kelvin (K) scale; this, when multiplied by the Boltzmann constant k, is a measure of the disordering energy of thermal agitation which is necessary to counteract the ordering of ferromagnetism; it is about 1,000 C in iron.

FERRITES

THE RELATION of the atomic moments and interaction to atomic structure and interatomic distance are well illustrated by the properties of the ferrites. These are refractory materials composed of the oxides of iron and other metals, usually Mn, Co, Ni, Cu, Zn, or Mg. They are pressed in powder form to the required shape and fired. Chemical reaction then occurs, and when they are cooled to room temperature they are hard, strong, and brittle.

Nickel ferrite, for example, has the chemical composition represented by $NiO.Fe_2O_3$, or $Ni^{++}Fe_2^{+++}O_4^{--}$. The crystal structure is determined mainly by the oxygen ions, which are much larger than the metal ions and form a close-packed cubic array. In among the oxygen ions there are two kinds of interstices in which the metal ions lie. In one kind of position (A position), the metal ion is equidistant from four oxygen ions, arranged at the corners of a tetrahedron; in the other kind (B position), the metal is placed so that there are six equidistant oxygen ions placed at the corners of an octahedron.

There are two ways in which the metal ions are distributed among the A and B sites. In $ZnFe_2O_4$, the Zn^{++}s occupy the A sites and the Fe^{+++} the B sites. Ferrites that have this distribution are nonmagnetic. In the magnetic ferrites, such as $NiFe_2O_4$, half of the iron ions are in the A sites; the other half and all of the divalent ions, such as Ni^{++}, are in the B sites. The former structure is generally designated a normal spinel structure, the latter an inverted spinel.

The magnetic moments of the metal ions can be deduced from the diagrams of the kind shown in Fig. 1. The moments of the ions that occur most frequently in the ferrites are given in Table I.

Table I. Atomic Structure and Magnetic Moments of Some Iron-Group Ions

Spin	First Shell	Second Shell	Third Shell	Fourth Shell	Net Moment
+	1	1,3 26 Fe	1,3,5	1	4(2.2)*
−	1	1,3	1,3,1	1	
+	1	1,3 23 Fe^{+++}	1,3,5	0	5
−	1	1,3	1,3,0	0	
+	1	1,3 23 Mn^{++}	1,3,5	0	5
−	1	1,3	1,3,0	0	
+	1	1,3 24 Fe^{++}	1,3,5	0	4
−	1	1,3	1,3,1	0	
+	1	1,3 25 Co^{++}	1,3,5	0	3
−	1	1,3	1,3,2	0	
+	1	1,3 26 Ni^{++}	1,3,5	0	2
−	1	1,3	1,3,3	0	
+	1	1,3 27 Cu^{++}	1,3,5	0	1
−	1	1,3	1,3,4	0	
+	1	1,3 28 Zn^{++}	1,3,5	0	0
−	1	1,3	1,3,5	0	

*Net moment is 4 in a free atom; 2.2 in the compact metal.

Néel[4] showed that in the magnetic ferrites the interactions between the ions in the A and B sites are antiferromagnetic, so that the moments of A ions are antiparallel to those of B ions. In magnetic $NiFe_2O_4$ and nonmagnetic $ZnFe_2O_4$, one can represent the situation by

	Tetrahedral A Sites	Octahedral B Sites	Net Moment (Nu)
$Fe(Ni\ Fe)O_4$:	Fe^{+++}	$Ni^{++},Fe^{+++}\ O_4^{--}$	
Moments:	→	← ←	2
	5	2 5	
$Zn(Fe\ Fe)O_4$:	Zn^{++}	$Fe^{+++},Fe^{+++}\ O_4^{--}$	
	0	← →	0
		5 5	

The net moment of $NiFe_2O_4$ is then expected to be 2 Bohr magnetons; experimentally, Gorter found 2.3. At room temperature, $ZnFe_2O_4$ has random directions of the Fe^{+++} moments, but below 10 K the Fe^{+++} go into an antiparallel arrangement, and so show a weak antiparallel or negative interaction.

Similarly, one can estimate the moments for the other ferrites in the series: Mn, Fe, Co, Ni, Cu, Zn. In the inverse ferrites one expects the molecular moment to be just that of the divalent ions of these elements, because the 2 Fe^{+++} in the A and B positions cancel each other. Using the moments of the divalent ions as given in Table I, and plotting the molecular moments for the corresponding ferrites, one obtains the straight line of Fig. 3. The observed moments, derived from the saturation magnetization at 0 K, are shown as points. The small discrepancy between calculated and observed moments has been at-

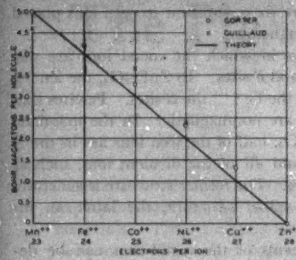

Fig. 3. Theoretical and measured molecular moments of ferrites of iron-group elements

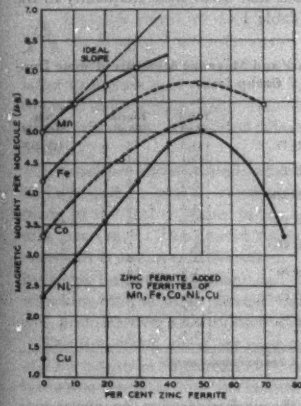

Fig. 4. Observed change in moment of several ferrites by addition of zinc ferrite. Ideal theoretical increase is approached for small additions

tributed to the moments resulting from the orbital motions of the electrons.

The agreement between theory and observation shows that there is good understanding of the atomic structure and interatomic interaction in simple ferrites.

An interesting and useful material is made by combining magnetic manganese ferrite with a small amount of nonmagnetic zinc ferrite. One can calculate the magnetic moment of a mixture of 90 per cent $MnFe_2O_4$ and 10 per cent $ZnFe_2O_4$ with the aid of the moments given in Table I.

	Tetrahedral A Sites	Octahedral B Sites		Net Moment (Na)
Inverse Structure:	Fe^{+++}	$Mn^{++}Fe^{+++}$	O_4^{--}	
Moments:	→	← ←		5
	5	5 5		
Normal Structure:	Zn^{++}	$Fe^{+++}Fe^{+++}$	O_4^{--}	
Moments:	0	5 5		0
		(Random)		
0.9 Fe(Mn Fe)O_4 + 0.1 Zn(Fe Fe)O_4	$Zn_{0.1}^{++}Fe_{0.9}^{+++}$	$Mn_{0.9}^{++}Fe_{1.1}^{+++}$	O_4^{--}	
	→	← ←		5.5
	0 4.5	4.5 5.5		

As indicated, pure $MnFe_2O_4$ has the inverse structure* and the Mn^{++} and Fe^{+++} each have a moment of 5 magnetons. The Fe^{+++} in the *A* position maintains the Mn^{++} and Fe^{+++} moments antiparallel to it, as shown by the arrows. In pure $ZnFe_2O_4$, the Zn^{++} is in the *A* position and has zero moment, the Fe^{+++}s are in the *B* position and have 5 Bohr magnetons each. Since the Zn^{++} has zero moment there will be no force of interaction between it and the two Fe^{+++}s, so the latter will be directed at random and the net moment will be zero. In $MnFe_2O_4$, on the contrary, the net moment is 5.

If now some $ZnFe_2O_4$ is added to $MnFe_2O_4$, the Zn^{++} ions will go in the *A* positions, and the Mn^{++} will remain in the *B* position. The net moment of the chemical mixture, as calculated, is found to be 5.5, an increase of 0.5 over that for $MnFe_2O_4$. As long as added Zn^{++} ions go in the *A* position one should expect the moment to rise as indicated by the upper broken line of Fig. 4 (ideal slope), which has this same increase of 0.5 Bohr magneton for each addition of 10 per cent of $ZnFe_2O_4$. Actually, the experiments of Gorter[5] give the data of Fig. 4 for additions of $ZnFe_2O_4$ to several of the simple ferrites. The first additions give curves starting with the ideal slope. Eventually the moments of ions in the *A* position are too weak to influence the moments of ions in the *B* position and the mixture becomes nonmagnetic like pure $ZnFe_2O_4$.

The technical value of the ferrites depends not only on their magnetic properties but also on their electrical resistivities. These are one million to one billion times the resistivities of the common magnetic alloys like silicon-iron and permalloy. The significance of these high values is the reduction of eddy-current losses in a transformer core or other similar structure that is subjected to alternating magnetic fields. At high frequencies, these low losses are especially important and practically determine the quality of the material. As a measure of the quality, $Q = 2\pi fL/\Delta R$, L being the inductance at the frequency f of a coil of wire containing the material, and ΔR the effective resistance of the coil caused by the presence of the material.

The factor of merit of a material of this kind is μQ, μ being the permeability. In Fig. 5, μ and μQ are plotted against frequency for zinc manganese ferrite, and are compared there with a high-quality iron-nickel alloy, molybdenum permalloy. Because of the high resistivity of the ferrite, its μQ declines less with increasing frequency, and at 1 mc the μQ is 50 to 100 times as great as for the alloy. This is in spite of the fact that: (1) the permeability of the alloy at low frequencies is about 10 times as great as the ferrite; and (2) the alloy is severely laminated so as to reduce the eddy current loss, whereas the ferrite is a solid piece of material.

The hysteresis loops of two of the common ferrites are

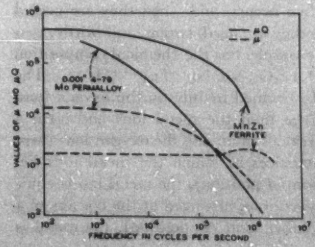

Fig. 5. Effective low-field permeability μ, and product with quality factor Q (reciprocal of energy loss) as dependent on frequency

*However, neutron diffraction experiments indicate that $MnFe_2O_4$ is only partially inverted. Since Mn^{++} and Fe^{+++} have the same moment this makes no difference in the net moment of the compound.

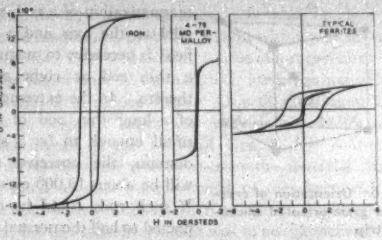

Fig. 6. Hysteresis loops of nickel ferrite and zinc manganese ferrite (smallest loop) as compared with loops of metallic iron and molybdenum permalloy

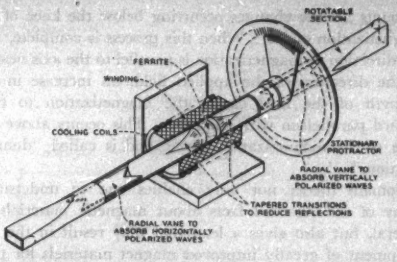

Fig. 8. Rotation of plane of polarization in wave guide resulting from transmission through magnetized ferrite (Faraday effect)

shown in Fig. 6, where they are compared with those for molybdenum permalloy and iron. It is apparent that the ferrites have lower saturation than the metals.

HIGH-FREQUENCY PHENOMENA

THE FERRITES have been observed at high frequencies, and give promise of important industrial applications as well as further insight into the behavior of magnetic materials. These properties come about mainly because the uncompensated electron spins of ferromagnetic materials precess under the influence of a magnetic field, just as a gyroscope precesses under the influence of gravity.

Imagine an electron traveling in an orbit and suspended in space as shown in Fig. 7. The magnetic moment caused by the orbital motion of the electron and also by its spin can be represented by the vector M. Antiparallel to M is the vector J which represents the angular momentum of the electron. If a magnetic field H is applied as indicated, the vectors M and J will precess with the frequency $MH/(2\pi J)$.

If a small-amplitude alternating field H_{rf} is applied, having a direction perpendicular to H and a frequency equal to or near the precession frequency, the amplitude of the precessing magnetic moment will become larger and larger, because it is continually pulled by the alternating field, until a final amplitude is reached which depends on the internal damping or energy loss associated with the precession. Measurement of the amplitude of the magnetic moment obtained with a given alternating field enables one to calculate an effective permeability. By varying the frequency of H_{rf} until the permeability is a maximum (at resonance), one can determine the natural frequency of precession.

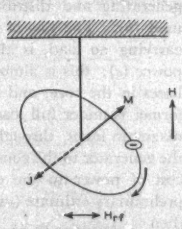

Fig. 7. Spinning electron in orbit. Magnetic moment M and angular momentum J precess under influence of applied field H. Radio-frequency field H_{rf} is applied perpendicular to H for resonance

Hogan[8] observed that if manganese ferrite is placed in a wave guide as shown in Fig. 8, the plane of polarization of the electromagnetic wave is rotated through large angles. On entering at the left, the polarization is perpendicular to the short dimension of the wave guide. The wave may be considered as made of two circularly polarized waves rotating in opposite directions. In one of these waves, the direction of rotation is the same as that of the precession of the spinning electrons, consequently the effective permeability of this component will be high and the wave velocity small as compared with the other wave which will have only a small reaction with the electron spins. Therefore, one wave component will fall behind the other and there will be a rotation of the resultant plane-polarized wave, as in the Faraday effect for light.

A specimen a few centimeters long of manganese ferrite, or preferably of magnesium manganese ferrite, will rotate the plane of polarization in a 3-cm wave by 90° or more. The amount of rotation can be adjusted by changing the field applied to the ferrite. Since the material is transparent to these waves as long as the frequency is not too near resonance, the transmission loss is slight.

There are many possible applications of this device. If the material and field are adjusted for a 45° rotation, and the rectangular waveguides properly oriented, a signal will pass in the forward direction with only a small loss. A signal going in the opposite direction, however, will be turned so that it will not be transmitted back beyond the ferrite into the rectangular wave guide. Thus, waves reflected backwards in a transmission line will be reduced practically to zero.

DOMAINS AND PERMANENT MAGNETS

THE DISCUSSION in the foregoing has shown the essential roles of atomic moment and interatomic force. In considering the change of magnetization with field the domain structure of a material is of prime importance.

In an unmagnetized piece of magnetic material separate regions or domains exist, in each of which the atomic moments lie parallel to each other along an axis of easy magnetization. Since there are six such directions in iron (eight in nickel), an unmagnetized or demagnetized iron crystal will normally have one-sixth of its domains oriented in each of the six directions, the average magnetization of the whole crystal being zero.

When a field is applied, the magnetization is normally changed by motion of the domain wall. This mechanism

accounts for the changes occurring below the knee of the magnetization curve. When this process is complete, and the direction of magnetization is parallel to the axis nearest to the direction of the applied field, an increase in the strength of the field causes the magnetization to turn toward parallelism with the field. This occurs above the knee of the magnetization curve, and is called "domain rotation."

Domain theory not only enables one to understand many of the essential facts about magnetic materials in general, but also gives a lead that may result in the development of greatly improved magnet materials for permanent magnets. If one could put together particles of iron of just the right size, shape, and orientation, a better magnet than any now in existence could be made.

The theory underlying this is as follows: Imagine two cubes of single crystals of iron, one without domain walls and one with. The first is magnetized so that it has poles on two of its surfaces, and as a result it has a large external field and a magnetostatic energy associated with it. The second cube has no energy of this kind, but it does have energy associated with its domain walls. The magnetostatic energy varies as the cube of the cube edge, and the wall energy as the square; consequently, the second cube will have the lesser energy when the particle is small. In iron the critical size is about 300 Angstroms. Since the normal wall thickness is larger than this, one can readily believe that there will be no wall in a particle of this size. Such small particles are then single domains; however, if they are too small they are disturbed by thermal fluctuations, therefore there is an optimum size.

In these small particles the mechanism of magnetization must be quite different from that in larger particles. Absence of domain boundary movement means that the only way for the magnetization to change is for the atomic magnets to rotate. This requires a greater force to be supplied by the field, because the magnetization must be turned through the direction of hard magnetization. The field necessary to pull the magnetization over the energy maximum is the coercive force of the particle, necessary to reverse the magnetization in the specimen. It can be calculated from the known properties of the crystal, and the data for iron check the calculation. Coercive forces of over 500 oersteds have been measured in fine iron powder, whereas the coercive force of large pieces of iron is normally about 1 oersted.

If the fine particles are not cubes or spheres, but are elongated—for example, if they are rods—an even higher coercive force may be expected. The direction of easy magnetization of a rod is parallel to the axis and a high field is necessary to magnetize a thin rod at right angles thereto. In the extreme case of a long thin rod of iron, small enough to be a single domain, the coercive force will be about 10,000 oersteds. If such rods could be compacted to half the normal density of iron, the quality could be 5 times as good as the best materials now available, so that permanent magnets could be made only one-fifth as large as they are now.

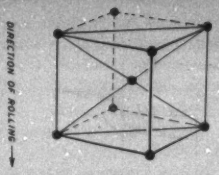

Fig. 10. Orientation of crystals in grain-oriented silicon-iron strip

The best material now available commercially is Alnico *5*, developed originally at the Philips Laboratory in Holland. This is a cast alloy containing Fe, Co, Ni, Al, and Cu. Some time ago it was proposed independently by Stoner and Wohlfarth[7] and by Néel[8] that this material is really a fine powder magnet; the phases present in the alloy are of two kinds, each present as very fine particles. Recently Heidenreich and Nesbitt[9] have observed such a structure with the help of the electron microscope, and have shown that the properties depend on the needle-like or plate-like shape of these fine particles. The directions in which the needles or plates are oriented depend on the heat-treatment of the material, which is cooled from a high temperature at a controlled rate in the presence of a strong magnetic field.

IRON-SILICON ALLOYS

THESE ALLOYS are still the big business of magnetic materials. It has already been mentioned that the annual product is valued at more than $100 million. The value of the yearly loss of magnetic energy in the cores of transformers, generators, motors, and other electric equipment is probably several times this amount. A rough estimate can be made (see equation): The annual production of electric energy in the United States in 1953 was over 400 billion kwhr (*a*), from which a revenue of almost $7 billion was derived. The installed capacity in this country for generating and distributing power is almost twice that used (*b*). The loss of an excited transformer, when it is carrying no load, is about 1/2 of 1 per cent of its rated power (*c*); this is almost entirely because of the magnetic losses in the core, and is about the same when the transformer is under full load. The number of steps involving magnetic losses, through which power normally goes from the generator to the consumer, is about 4 (*d*). The average cost of power to the consumer is 1.8¢/kwhr (*e*). As a preliminary estimate (using the figures given as (*a*), (*b*), . . .) then

$$400\times10^{9}\times2\times0.005\times4\times\$0.018=\$300\times10^{6}$$
$$(a)\quad(b)\quad(c)\quad(d)\quad(e)$$

This is too low for one reason and too high for another; too low because the magnetic losses in motors and other kinds of consumer equipment must be added and the losses in generators are higher than in transformers; too high because some of the industrial power is consumed without

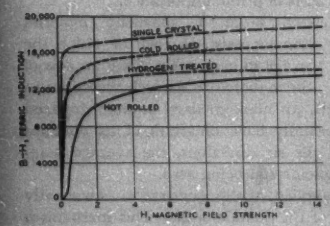

Fig. 9. Comparison of commercial cold-rolled (grain-oriented) silicon iron with hot-rolled (nonoriented) material. Purification of nonoriented material by hydrogen treatment is beneficial in low fields

passing through so many stages. It must be right as to order of magnitude, probably is right within a factor of two. In any case, it is an important source of lost revenue.

The importance of the magnetic losses has naturally led to attempts to reduce them. One of the largest reductions in magnetic losses was made in the 1930's largely as the result of the work of Goss.[10] His contribution was to so fabricate and heat-treat the material that the individual crystals were oriented in the sheet with their directions of easy magnetization parallel to the length of the sheet, the direction in which it was to be magnetized in use. Measurements of single crystals of silicon-iron[11] show that to magnetize them to $B = 15{,}000$ in the direction of easy magnetization requires a field of only 0.1 oersted, while in the direction of hard magnetization this requires 100 oersteds, or 1,000 times as much.

The method of fabrication and heat-treatment used by Goss has been adapted to commercial production by several large steel companies. A product is now readily available which approaches the properties of a single crystal, as shown in Fig. 9. The alignment of crystals can now be so controlled that most of the crystals have a direction of easy magnetization within 10° of the rolling direction of the sheet. The orientation[12] taken by the unit cube of the crystals is depicted in Fig. 10.

The quality of the present-day silicon-iron is influenced markedly by another factor, the impurity content. In the transformer core material produced in 1890, it is reported that about 1 per cent carbon was present as an impurity. In 1905, the first silicon-iron sheet contained about 0.1 per cent carbon. In the hot-rolled product of a decade ago the content was about 0.03 per cent; in present-day cold-rolled material it is probably less than 0.01 per cent. The carbon present in this material as it comes from the rolling mills is reduced by treating in moist hydrogen at about 800 C, and further reduced during the final high-temperature treatment of the strip at 1,100 to 1,200 C in dry hydrogen. Important work on the removal of various impurities from iron by hydrogen was carried out over a period of years by Yensen,[13] Cioffi,[14] and others.[15]

The difference in power loss of hot-rolled and grain-oriented (cold-rolled) material, produced commercially,

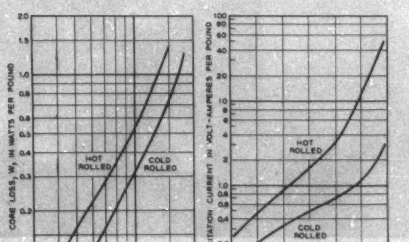

Fig. 11. Core losses and exciting current (in watts/pound) in hot-rolled and cold-rolled material

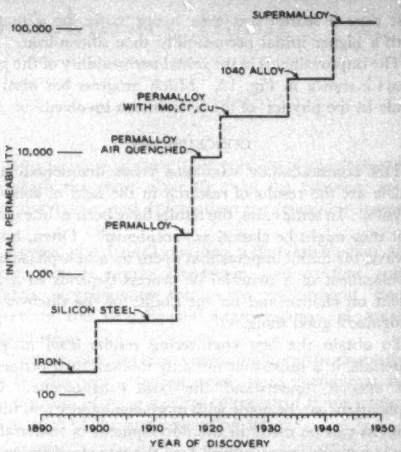

Fig. 12. Improvement in initial permeability of material in the last half century

is shown[15] by the curves of Fig. 11, where a 2-fold improvement is apparent. The exciting current may also be reduced 10 fold.

It has been known for many years that fabrication and annealing effect a nonrandom orientation of the crystals composing metallic materials. Although something is known of the nature of slip on certain crystal planes, and the growth during annealing of crystals in certain preferred directions, a real understanding of the mechanism of grain-orientation in silicon-iron and other metals is still lacking. The early stages in the development of grain-oriented transformer sheet were actually carried out without the knowledge that the crystal grains were oriented in a special way by the processing. The understanding of the results in terms of crystal orientation, however, enabled the development to proceed more rapidly and to a further extent. This understanding was provided by solid-state physics.

IRON-NICKEL ALLOYS

In contrast to the iron-silicon alloys, which are used to transmit large amounts of power, the iron-nickel alloys are used mainly to detect and transmit the small signals used in communication. The small signal currents produce small magnetic fields inside of transformers and other equipment, and it is therefore desirable to make the flux (voltage) response as high as possible. The material should then have a high permeability in low fields. Whereas in power transformers the induction may have an amplitude of 15,000 gauss, in communication transformers it may be much less than 100 gausses. The first criterion of a material for this use is the initial permeability μ_0, the limiting ratio of B/H which is approached as H becomes indefinitely small.

The outstanding qualities of the iron-nickel alloys (permalloys) were reported by Elmen in 1916. For the

first time a search was then being made for a material with a higher initial permeability than silicon-iron.

The improvements in the initial permeability of the perm-alloys is shown in Fig. 12. Much progress has also been made in the physics of the phenomena involved.

CONCLUSIONS

THE COMMERCIALLY VALUABLE ITEMS mentioned in this article are the results of research in the field of solid-state physics. In some cases, the results have been so unexpected that they might be classed as "accidents." Often, but not always, the initial impetus that opens up a new phase in the development of a material or process depends to a large extent on chance and on the ability of the discoverer to recognize a good thing.

To obtain the best engineering results from magnetic materials, it is important not only to know their properties, but also to understand the basic phenomena. Then applications can be made with more intelligence and further progress can be made in the development of materials for uses in new situations, as well as in the more familiar ones.

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Model of Atomic-Power Generating Station Is Displayed

A model of a transportable atomic-power generating station, which will go into service in 1957, was on exhibition recently at the Carnegie Endowment International Center, New York, N. Y. Displayed by ALCO Products, Inc., Schenectady, N. Y., the model is one of several commercial versions of the Army Package Power Reactor (APPR), which will be built under contract of the Atomic Energy Commission.

The power plant, the Army's first nuclear reactor, is designed so that its components can be transported by air to remote locations anywhere in the world. The Army has announced an interest in using such power plants for distant early warning (DEW) line radar stations and other inaccessible locations where fuel transportation and availability are costly problems. To be built at the Army's Corps of Engineers post, Ft. Belvoir, Va., the first APPR will be used to train engineer personnel.

This display was a part of a large trade show entitled, "Man, the Atom, and the Future," sponsored by the Atomic Industrial Forum, the Fund for Peaceful Atomic Development, and the Carnegie Endowment for International Peace.

The model has previously been displayed at the "Atoms for Peace Conference" held in Geneva, Switzerland, in August, and at the Atomic Industrial Forum trade show held in Washington, D. C. It is scheduled to go on tour of Japan, and later will be sent to the agency's permanent exhibit at Bonn, Germany.

Close-up of model of the atomic-powered generating station. Shown within the specially designed vapor container are the nuclear reactor, primary pumps, and steam generator. Three water tanks can be seen in the foreground, while the feedwater and evaporator, essential to the closed-cycle pressurized-water system, are in the background.

Calculating Response to Arbitrary Input

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A BROAD UNDERSTANDING of the dynamic aspects of feedback control requires an appreciation of the factors affecting the response to a general or arbitrary input. The important characteristics of the response to an input can be readily determined if the important characteristics of a small set of transient responses are given. Thus, a few transient-response parameters are sufficient to specify in a practical sense the general time response of any linear system. A knowledge of the manner in which these parameters relate to the general time response is very helpful for analyzing the dynamic system requirements for particular applications, because it shows what characteristics of a specific input are the cause of dynamic error and what the requirements on the transient response are for keeping this error within allowable bounds.

There are three basic sets of characteristics which define the general time behavior of a feedback control loop: the transient terms, designated $T_n(t)$; the steady-state coefficients, designated c_n; and the initial-value coefficients, designated a_m. These characteristics appear in the responses to steps of derivatives and to steps of integrals of the input. The response to a unit step of the nth derivative can be expressed as:

$$x_0(t) = T_n(t) + c_n + c_{n-1}\frac{t}{1!} + c_{n-2}\frac{t^2}{2!} + \ldots + c_1\frac{t^{n-1}}{(n-1)!} + c_0\frac{t^n}{n!} \qquad (1)$$

The term $T_n(t)$ is the transient portion of the response and is called the nth-derivative transient term. The coefficients $c_0, c_1, \ldots, c_n$ are the steady-state coefficients, and c_n is the nth-derivative steady-state coefficient. If the error response were being considered, the steady-state coefficients resulting would represent the well-known error coefficients of the system.

The expansion of equation 1 for a step of the nth derivative can also be expressed as follows:

$$x_0(t) = c_0 x_i(t) + c_1 D x_i(t) + c_2 D^2 x_i(t) + \ldots + [c_n + T_n(t)] D^n x_i(t) \qquad (2)$$

where the symbol $D^n x_i(t)$ represents the nth time derivative of the input. From this expansion, the response to an arbitrary input which does not contain high-frequency components can be calculated by using the following procedure:

1. Approximate as steps those portions of the input which rise more abruptly than the system step response, and differentiate the remaining smooth curve.

2. Approximate as steps those portions of the derivative curve which rise more abruptly than the transient term for that derivative, and differentiate the remaining smooth curve.

3. Repeat step 1 until reaching a derivative where the transient term is nearly monotonic, and at that point completely approximate the curve by straight lines. Differentiate the straight-line approximation to obtain a series of steps.

4. To form the response curve, multiply the derivative curves by the corresponding steady-state coefficients and add to the sum of these a series of transient terms proportional to each of the approximating steps.

In this computation, comparatively low accuracy is required for the transient terms and the steady-state coefficients, so that a few parameters defining the gross characteristics of the transient responses can give an adequate description of the response to any input. Besides, relatively few segments are needed to approximate a given input, which makes it quite easy to see how the response to that input is affected by a particular transient-response characteristic. Feedback control systems are generally designed in terms of frequency response. Consequently, to employ this approach directly in design requires that the transient responses of a system be related to its frequency responses. Although there is no simple means of performing this relationship exactly, there are good reliable approximations which can be used. Only the gross characteristics of the transient responses need be known, and approximations of these characteristics that are perfectly adequate for design can be readily estimated from frequency response data.

If the input contains high-frequency components which rise and fall like pulses in periods which are short with respect to the step-response rise time, an average curve should be drawn through the input plot to separate out the high-frequency components. These components should be integrated successively, with step approximations being made at appropriate places. The method for computing the response to the high-frequency portion is based upon the following expansion of the response to a step of the mth integral of the input:

$$x_0(t) = a_0 x_i(t) + a_1 D^{-1} x_i(t) + \ldots + a_{m-1} D^{-(m-1)} x_i(t) + [T_{-m}(t)] D^{-m} x_i(t) \qquad (3)$$

where $D^{-m} x_i(t)$ represents the mth time integral of the input, and a coefficient a_m is called the mth-integral initial-value coefficient. The expansion shows that the response to the high-frequency portion is obtained by multiplying the integral curves by the corresponding initial-value coefficients, and adding to the sum of these a series of transient terms proportional to each of the approximating steps.

Digest of paper 55-553, "A Simple Method for Calculating the Time Response of a System to an Arbitrary Input," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Published in AIEE *Applications and Industry*, September 1955, pp. 227–45.

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Extruded High-Strength Aluminum for Electrical Bus Conductors

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C. L. CARLSON

The uses and electrical properties of extruded and heat-treated aluminum bus conductors are discussed. Results of tests conducted on various bus sizes and configurations are given.

ACCORDING TO LATEST PREDICTIONS, the electric power industry will double in size in the next 10 years. This means that there will be a corresponding increase in the amount of electrical equipment required and in the need for conductor material. Since the world supply of copper is insufficient to meet expected demands, the present trend is toward replacement of copper by aluminum wherever possible.

The electrical conductor (EC) grade of aluminum has been used for some time in many bus conductor applications. This material was developed primarily for the electrical industry and through close control of its composition, it has an electrical conductivity of 61 per cent of the International Annealed Copper Standard. It is essentially a high purity aluminum (99.45 per cent minimum aluminum content), hardenable only by cold work.

The highest strength commercially available in cold worked EC bus conductor is that of *EC-H17*, which has a minimum tensile strength of 17,000 pounds per square inch (psi). This is roughly half that of copper bus conductors.

Believing that switchgear and bus duct manufacturers would welcome it, aluminum suppliers recently developed and marketed a high-strength bus conductor alloy. This new material is similar to an extruded and heat-treated alloy introduced several years ago and much used in architectural applications. With some modification in the manufacture and treatment of this type of alloy, the electrical conductivity is enhanced sufficiently to make it attractive as a conductor. The original alloy used for many architectural applications was designated by the trade as *63S-T6*. This was changed recently to *6063-T6*. The *T6* refers to the heat treatment given the material to obtain strengths in excess of those possible with materials that are hardenable only by cold work.

A comprehensive program for evaluating this new alloy was planned and carried out. The program consisted of current-carrying and short-circuit tests on the earliest available samples of the materials mentioned above and mechanical, electrical conductivity, and fabrication tests on all suppliers' materials as they became available. The purpose of the latter part of this over-all program was to determine whether the current-carrying and short-circuit test data obtained for one of the high-strength materials were applicable to the other available materials. This proved to be true.

Table I lists mechanical properties and electrical conductivity found on samples of high strength aluminum bus conductor from four suppliers and on specimens of the standard architectural alloy, *6063-T6*. American Society for Testing Materials (ASTM) standard test methods were followed. Typical specification properties are also given in the table for *EC-H13* and for copper. It is evident that the electrical conductivity has been raised by the production control exercised by the various suppliers of these bus alloys. These values can be compared with those of the architectural alloy, which may have a conduc-

Table I. Properties of High Strength Aluminum Bus Conductor (1/4 Inch Thick Extruded Bar)

Material	Testing Temperature, C	Ultimate Strength (psi)	Yield Strength (psi) 0.2 Per-Cent Offset	Yield Strength (psi) 0.5 Per-Cent Extension	Elongation in 2 Inches, Per Cent	Hardness BHN 500 Kg	Hardness	Electrical Conductivity, Per Cent IACS at 23 to 25 C
Supplier A	28	31,900	29,350	29,300	15.0	69	(72)‖	55.51
	100	29,700	28,000	27,900	14.8			
Supplier B	28	34,050	30,800	30,550	12.4	75	77	55.40
	100	31,500	29,150	29,050	12.5			
Supplier C	28	35,550	32,500	32,650	11.6	78	80	55.11
	100	33,650	31,300	31,350	10.9			
Supplier D	28	30,650	26,850	26,800	15.6	58	(60)	56.76
	100	27,500	25,300	25,300	16.1			
*6063-T6**								
Actual	28	31,300	26,700	27,000	14.8	69	(72)	53.48
	100	29,050	25,100	25,000	15.3			
Typical	25–30	35,000	31,000	.....	12	73	..	53
Specification	25–30	30,000 (min)	25,000 (min)	.....	10(min)	..	..	...
EC-H13†								
Typical	25–30	17,000	16,000	.....	20	33	..	62
Specification	25–30	14,000 (min)	12,000 (min)	.....	...	..	..	61
Copper‡ Hard								
Typical	25–30	42,000	37,000	.....	25	74	(78)	100
Specification	25–30	33,000 (min)	.....	.....	15 (min)	(62)	65 (min)	98.4

*ASTM Specification *B221-54T* (Alloy *GS10A-T6*).
†ASTM Specification *B236-52T*.
‡ASTM Specification *B187-54*.
‖Parentheses indicate conversion values.
NOTE: Nominal composition of *6063* and of the high strength aluminum bus conductors listed in this table is 0.4 per cent silicon, 0.7 per cent magnesium, balance aluminum and normal impurities.

Essentially full text of paper **56-224**, presented at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956, and recommended for publication by the AIEE Committee on Switchgear. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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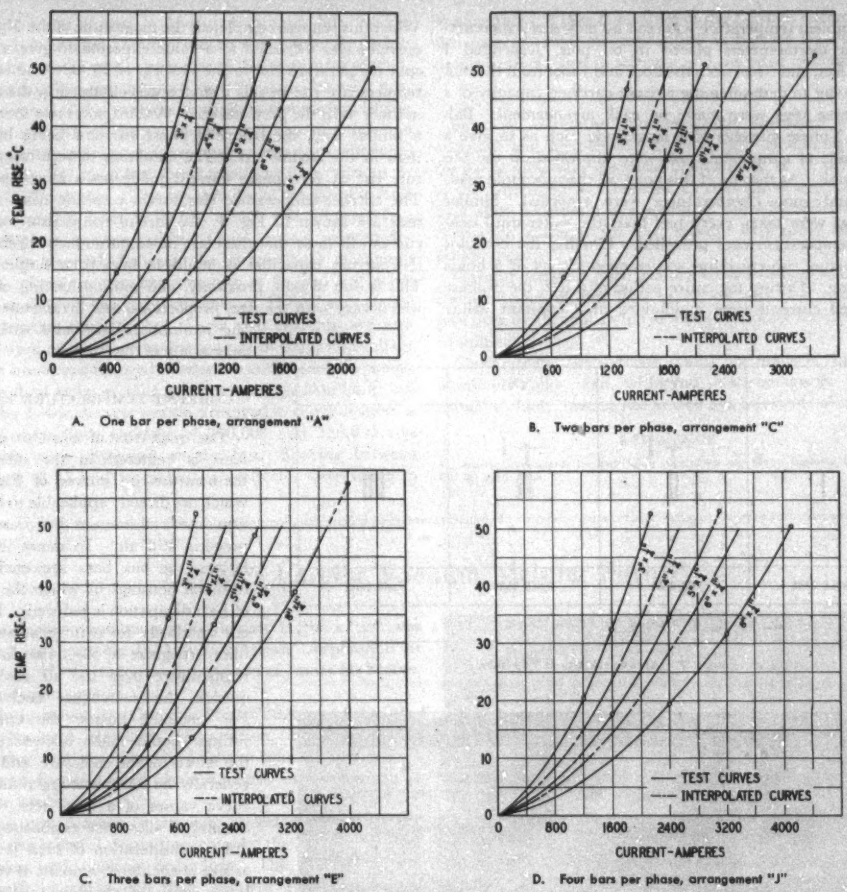

TEMP RISE-°C
CURRENT-AMPERES
TEST CURVES
INTERPOLATED CURVES
A. One bar per phase, arrangement "A"
B. Two bars per phase, arrangement "C"
C. Three bars per phase, arrangement "E"
D. Four bars per phase, arrangement "J"

Fig. 1. Current-temperature rise curves at 60 cycles for aluminum bus bars of various cross sections and in flat arrangement

tivity as low as 50 per cent. It is likely that the conductivity ordinarily supplied will be greater than shown here, inasmuch as these materials were ordered to be as close to 55 per cent conductivity as practical, for the current-carrying and short-circuit tests to be described later. Note also that the minimum tensile strength for copper is only 3,000 psi greater than that for the new conductor.

CURRENT-CARRYING TESTS

A SERIES OF TESTS was conducted to obtain the 60-cycle alternating current capacities of bus bars made of this particular aluminum alloy. The tests investigated 3-phase busses composed of flat aluminum bar using one, two, three, and four bars per phase. The cross-section dimensions are those shown in the current-temperature rise curves of Fig. 1. Their spacing and arrangement are indicated in Fig. 2 and are those commonly used in low-voltage metal enclosed switchgear.

The test bus was composed of 12-foot sections mounted on edge. The bars were not silver plated but in the "as-received" condition. The busses were mounted in open air on a rack as shown in Fig. 3. Air circulation was unimpeded, except for supports. The test area was surrounded by a wallboard partition forming an open top enclosure for eliminating air drafts.

The bus-bar temperatures were measured by copper-advance thermocouples and a potentiometer calibrated directly in degrees Centigrade. Thermocouples were swaged into blind holes 3/8 inch from the top edge. Their longitudinal placement along a bus bar is indicated in Fig. 4. At one location, additional thermocouples were swaged into the bars at their center lines and lower edges.

The ambient temperature was read by means of 3 mercury-in-glass thermometers placed in oil pots, suspended 1 foot, 3 feet, and 5 feet from the floor and 1 foot from the bus.

In order to determine the current-carrying capacity of a bus, three tests were made on each arrangement. Balanced 3-phase currents of a magnitude such as to give a low value of temperature rise were impressed on the bus for 1 hour. At the end of this hour, all thermocouple readings and room temperatures were recorded. Similar readings were taken every half hour thereafter until constant temperature rises prevailed. Usually, the constant temperature rise condition was reached after 4 or 5 hours of testing. During the entire period of a test, the 3-phase balanced currents were maintained at a constant value. When this test was completed, the magnitude of the 3-phase currents was increased to a value expected to give a hot-spot temperature rise in the vicinity of 35 C. The actual temperature rise in this instance was obtained in the same manner as in the previous test. A third point was found in a similar way, the balanced phase currents being higher than in the second test. The condition of zero temperature rise at zero phase current made up a fourth point. The current-temperature rise curves resulting from these tests are shown in Fig. 1. A careful comparison of the curves will show that there are no common factors relating the current capacities of multiple bars to a single bar. This is due to skin, proximity, and mutual heating effects which vary with the size, proportions, and arrangement of the laminations and also with the magnitude of the current.

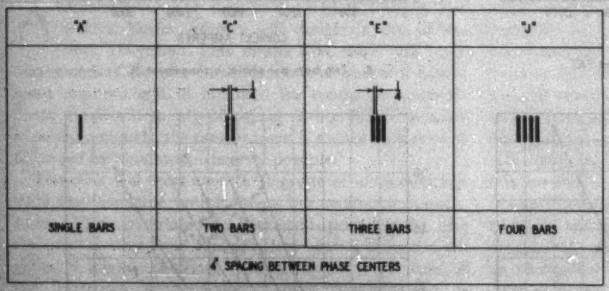


Fig. 2. Arrangements of bus bars

Fig. 3. View of aluminum bus with short-circuit supports and bus taps

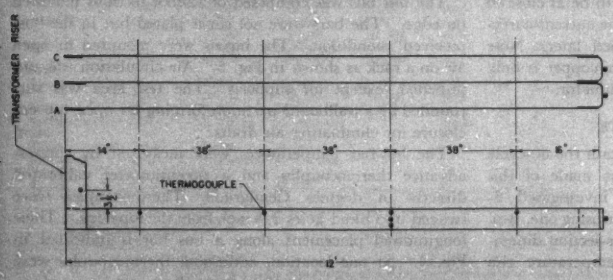


Fig. 4. Thermocouple locations on bus bars

CURRENT-TEMPERATURE RISE

THE SOLUTION of bus-bar problems is centered in the current-temperature-rise curves of Fig. 1, which are directly applicable to bare, unpainted, aluminum bus bars exposed in still air. In many installations, the bus bars are enclosed in metal housings in which the rate of heat dissipation is reduced. Present standards[1] for switchgear assemblies recognize a 50-C rise in bus temperature over the air ambient outside the switchgear enclosure. For enclosed busses, the current ratings should make allowance for the effects of the enclosure and will generally be somewhat less than the curve values of a 50-C rise. The amount of allowance established requires consideration of such factors as size of enclosure, amount of ventilation, path of air flow, radiating effects of ends and bends, intermittent loads, and nonuniform loading where there are several tap connections. The design engineer, in choosing bus sizes for switchgear assemblies, can supplement the curves by drawing upon the results of temperature rise tests of typical enclosed units and upon the performance record of operating equipment in determining reasonable allowances for enclosure effects.

SHORT-CIRCUIT TESTS

SHORT-CIRCUIT TESTS were also performed in addition to the current-temperature rise tests just described.

In one series of tests, a 12-foot aluminum bus, having a 3- by 1/4-inch cross section and arranged in configuration *A*, was connected to a copper bus of the same cross section. The spacing between supports was the same for each bus. The purpose of the test was to make a comparison of the relative strength of the two busses and also to determine what spacing between supports was necessary to withstand adequately the magnetic forces resulting from various 3-phase fault currents. The magnitudes of the 3-phase fault currents ranged from 35,000 to 60,000 rms amperes (average 3-phase asymmetrical). There was no marked difference in strength between the copper and aluminum busses. Spacings between supports of 26 and 21 inches were established for fault currents of 35,000 and 60,000 rms amperes respectively. These two currents are representative of the interrupting ratings of some low-voltage circuit breakers employed in selective and cascaded systems.

The final series of tests was made on an aluminum bus of 5- by 1/4-inch cross section arranged in configuration *A*. Three-phase fault currents of 100,000 and 150,000 rms amperes were impressed on the bus. Spacing between supports of 17 and 13 inches, respectively, were found to be adequate. These two values of short-circuit current are also representative of interrupting ratings of low-voltage circuit breakers used in selective and cascaded systems.

CONCLUSIONS

SEVERAL ALUMINUM SUPPLIERS have developed a new extruded and heat-treated high-strength aluminum alloy having a minimum electrical conductivity of 55 per cent of the International Annealed Copper Standard (IACS). This alloy provides a new source of suitable electrical bus conductor material for the rapidly expanding electric power industry.

Current-carrying tests, performed on various sizes and configurations of bus bars made on this new material, give data for its application as a bus conductor for electrical equipment.

Short-circuit tests indicate that a bus made of this new aluminum alloy can withstand electromagnetic forces caused by fault currents just as well as a bus made of copper.

REFERENCE

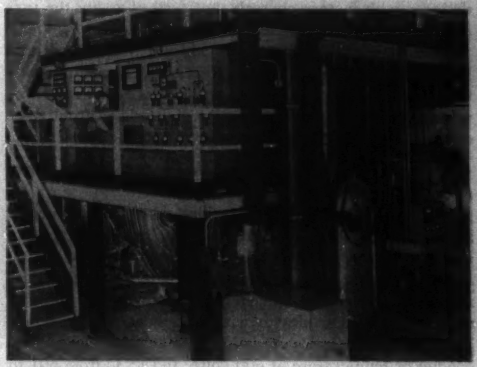
1. American Standards for Switchgear Assemblies and Metal Enclosed Bus, *ASA C37.20*, 1955, p. 10.

Nation's Largest Vacuum Melting Furnace

The largest vacuum melting furnace in the nation was tapped in December by Vacuum Metals Corporation at Syracuse, N. Y., under the supervision of James H. Moore, general manager.

Jointly owned by Crucible Steel Company of America and National Research Corporation, Vacuum Metals was the first commercial producer and the first fully integrated producer of vacuum-melted metals and alloys in the country.

This new furnace is remotely operated by the melter, who can control from one console the charging, mold transfer, and pouring operations. The melting unit is enclosed in a 3/4-inch thick air-tight and liquid-cooled stainless steel chamber, with connecting air lock chambers for charging raw materials and discharging ingots. The design makes it possible to charge, melt, pour, and remove ingots without affecting the vacuum in the melting chamber. The mold-handling mechanism makes it possible to cast ingots of varying sizes and shapes, either singly or in multiples, from a single heat.



The design, which was based on five years of operating experience with such semicontinuous vacuum furnaces, was under the direction of Dr. M. H. Hnlicka of the research division of National Research Corporation. The furnace was built by the Equipment Division of National Research and installed by the engineering department of the Sanderson-Halcomb Works of Crucible Steel, under the direction of W. K. Lowe, chief engineer. The new unit increases by 60 to 75 tons the monthly potential supply of vacuum-melted metal for industry.

The products of this process are characterized by cleanliness and low gas content, with consequent higher elevated temperature strength and ductility, and increased fatigue and impact strengths. They have proved superior for use in critical applications in aircraft engines and in machinery components requiring a quality unattainable from conventional metal.

A number of experimental evaluations and production trials made from vacuum-melted metals in such important industries as aircraft, automotive, electronics, bearing, tool steel, nuclear energy, and many others have prompted the Vacuum Metals Corporation to be optimistic about the future and to look forward to providing additional furnace capacity to meet a growing demand for vacuum-melted metals.

An Evaluation of Butyl Rubber Insulated Cable

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PRIOR TO THE DEVELOPMENT of butyl rubber, high-voltage ozone-resisting compounds utilized natural rubber, which requires complete protection by thoroughly dispersing the natural rubber in a vegetable oil derivative or "factice." This coated the rubber particles and protected these highly unsaturated molecules from attack by oxygen, ozone, and ultraviolet light. These oil-base insulations, when carefully formulated and processed, have given excellent service within their limits of operating temperatures and environment. However, as with all materials such limitations do exist and, thus, generate the constant search for materials with improved inherent properties.

The early evaluations of butyl rubber insulations confirmed the theoretical excellence of this "tailor-made" copolymer as being strongly resistant to oxygen, ozone, sunlight, heat aging, and other factors which normally attacked natural rubber or unsaturated elastomers.

Various cable assemblies have been investigated by modern testing techniques, not only to determine their ability to meet operating conditions, but also to provide the designer with factory controls that further assure the user against defects that could lead to service outages.

Data have been obtained on cables manufactured with butyl rubber insulation over a period of 11 years, supporting the theoretical conclusion as to the excellence of this material when used as a high-voltage solid dielectric. From these data, it is concluded that:

1. Butyl rubber insulated cables have exceptional resistance to the effects of oxygen and ozone.

2. Butyl rubber insulated cables show no evidence of sun-checking or surface weathering after long-time exposure to moderately corrosive industrial atmospheres.

3. Extended temperature tests, up to 5½ years, and numerous accelerated aging tests prove the ability of butyl rubber insulated cables to withstand heat aging. These data permit the service operation of these cables up to 90 C conductor temperature at 600 volts, and 85 C from 601 to 15,000 volts, with the assurance of long economic life. These tests, as well as load-cycle aging tests, demonstrate the ability of these cables to operate up to 125 C conductor temperatures (depending on voltage rating) under emergency loading conditions for periods of 100 hours per year.

4. Butyl rubber insulated cables have exceptional resistance to moisture absorption at elevated temperatures.

5. Assured absence of internal ionization in cable constructions is essential, particularly at higher voltages. Use of corona extinction voltage detecting equipment as a quality control procedure results in improved cable design and provides assurance of freedom from internal ionization.

6. Dielectric strength of butyl rubber insulated cable is more than adequate for all service conditions. Tests have shown that the impulse strength and switching surge strength are in excess of values normally expected to be encountered.

7. Butyl rubber insulated cables designed with proper types of conductor and insulation shielding retain their ionization levels after bending and temperature cycles.

8. Load-cycle testing, with and without overvoltage, demonstrates the ability of butyl rubber insulated cables to retain their excellent thermal and electrical properties under conditions of thermal expansion.

From 1944 to 1955, a total of 13.5 million conductor feet of butyl rubber insulated power cable has been produced by the company with which the authors are associated. This cable ranges in conductor size up to and including 1,500 MCM (thousand circular mils), and in voltage ratings up to and including 15-kv ungrounded neutral, and represents 10,270 mile-years of operation. Although the early service experience was relatively unsatisfactory due to unforeseen difficulties in applying the new material, the program of better shielding and corona-level testing, coupled with improved manufacturing techniques, has resulted in an excellent service record. Included in the total produced since 1949 is 2.8 million feet of 15-kv cable which has operated with only one service failure attributable to a manufacturing defect.

Therefore, although this insulation is relatively new in comparison with the older types of natural rubber and oil-base compounds, it is apparent that its inherent characteristics, as well as its widespread utilization to date, will make it even more attractive to power-cable users in the future. Even though the prewar rubber compounds have enjoyed an enviable record of service, it is doubtful that they have been called upon to operate up to full capacity for a very large percentage of their life. Yet it is well known from annual statistics that the kwh output per kw of installed capacity has been steadily increasing for the last 20 years. It is, therefore, a safe assumption that a great many cables in the past have operated at full capacity only a small percentage of the time and that they will be fully loaded in the future. This means that for a given maximum allowable copper temperature, the over-all average temperature will be considerably higher than it was 20 or 30 years ago. If this average increase is in the order of 10 C, it is probable that the life of cables utilizing the older types of insulation will be cut in half. The increased loads and overloads of the future will require such "tailor-made" insulations as butyl rubber.

Digest of paper 55-668, "Design and Evaluation of Butyl Rubber Insulated Power Cable," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Digital Calculation of Network Impedances

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THE OPERATION of an electrical network may be defined by means of driving-point and transfer impedances. According to the American Standard Definitions of Electrical Terms, the driving-point impedance at any pair of terminals of a network is the ratio of an applied potential difference to the resultant current at these terminals, all terminals being terminated in any specified manner. Similarly, the transfer impedance between any two pairs of terminals of a network is the ratio of a potential difference applied at one pair of terminals to the resultant current at the other pair of terminals, all terminals being terminated in any specified manner.

Driving-point and transfer impedances as a circuit-analysis technique have been widely used in such electric utility engineering problems as load-flow, short-circuit, regulation, stability, and transmission-loss studies. In stability studies, the driving-point and transfer impedances are measured with all other terminals being short-circuited. In other studies, the driving-point and transfer impedances are measured with all other terminals open and are then designated as self and mutual impedances.

The self and mutual resistances of the transmission system are used in several methods of calculating transmission loss formulas. These resistances are usually obtained by measurements on the network analyzer and then transcribed to punched cards for calculations undertaken by an automatic digital computer.

Three digital methods of calculating self and mutual impedances that have been successfully programmed for an automatic digital computer are described. Method I is an application of Gabriel Kron's method of analysis of stationary network, and involves straightforward matrix operations. Method II defines the network in terms of tracks and loops, and determines the solution by superimposing a set of balancing currents upon an assumed set of currents. Both of these methods are direct, in that the answers produced are accurate within the precision carried in the problem solution. Method III is an iterative method in which an assumed set of voltages is successively improved until satisfaction of Kirchhoff's laws has been achieved within the precision desired in the problem solution.

The specific computer used by the authors in the development of these methods was the International Business Machines Corportion (IBM) Type *650* magnetic drum data processing machine shown in Fig. 1. A summary of the time required for this machine to obtain the self impedances of all generators and the mutual impedances between the generators and all busses is tabulated below for a system consisting of 30 busses, 38 lines, 14 loops, and 5 autotransformers representing off-nominal turn ratios, as follows:

Fig. 1. Type-650 computer installation in General Electric Company analytical engineering section

Method	Computer Time in Hours
I	4
II	1
III	2

Method I requires a shorter program, but more data storage than Method II. These two programs are prepared for a maximum of 15 loops and 60 lines but may be extended by using cards as temporary storage. Methods I and II require the inversion of a matrix equal in size to the number of loops and, consequently, are both limited in this respect.

These three methods offer several distinct advantages over previous analogue methods:

1. Much greater degree of accuracy is obtained.
2. Vastly lower cost per operation becomes possible.
3. Set-up time is very small as general programming decks are available.
4. They eliminate the necessity for transcribing network analyzer results to punched cards, and the associated time and possibility of error when these self and mutual impedances are required for digital-circuit studies.

The techniques described may also be applied to the determination of driving-point and transfer impedances for cases in which the terminals are terminated in any other specified manners.

Digest of paper 55-680, recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3-7, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Location and Design of Distribution Substations in Residential Areas

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For good public relations, a utility must give consideration in substation designs for residential areas to such factors as appearance and noise. A number of modern installations are described, which have been successfully used in making substations less conspicuous and, thus, more acceptable to nearby residents.

AS ELECTRICAL-UTILITY LOADS continue to grow and the distribution systems become more dense, it usually follows that distribution substations become more numerous and closer together than formerly. In general, the proper size, spacing, and location of substations are matters of engineering and economics, and can be readily determined for a particular utility system. Such calculations usually point up the importance of placing the substation very close to the theoretically ideal location, even though special measures may be necessary to meet the requirements of the surrounding community.

In urban and suburban sections, this results in many of the substations necessarily being located in residential or commercial areas, sometimes of a very high type. Although acquiring the desired site can be quite a problem, the matter of public relations is usually the overriding consideration.

This article discusses items which are important because they frequently have a bearing on the latter. Illustrations (Figs. 1–6) are typical examples of various aspects of the problem and the ways in which they have been met. Three major considerations are:

1. *Appearance.* The feature of a substation most frequently of concern to the surrounding residents and others is its appearance. This has many significant aspects and can be coped with in many different ways. (Appearance will be presented in a brief manner and with photographs with descriptive captions.)

2. *Noise.* Another feature of special concern, and strongly so when present, is noise emanating from the station. (This important consideration relating to noise from substations and how they may be dealt with will be covered only briefly here.)

3. *Zoning.* Before construction may begin for a new substation in a residential area, it is necessary, of course, to comply with local regulations to obtain a zoning variance permit, to take appropriate steps to have the regulations modified, or to secure special authorization in cognizance of the need. It is not to be implied that rezoning is usually necessary for, in most instances, this is not the case.

APPEARANCE

For Public Acceptance. From an appearance standpoint, a substation will be acceptable to the nearby residents if it has been adapted to the neighborhood. The treatment which the public sees should be such that it blends in with its surroundings, that the over-all impressions it gives are pleasing ones, that it is unobtrusive, and insofar as possible that it will enhance the appearance of the nearby properties. If this is done, it will not only receive acceptance in that neighborhood, but also will create favorable impressions in the minds of residents of other localities where similar installations may be proposed. It is believed that this will, in time, correct the inherent opposition to substations which now seems to exist in the public mind.

Obviously, different types of residential areas and different types and sizes of substations call for different treatment as to appearance. In some instances, only a neat and safe arrangement together with good maintenance will be required. Generally, substations facing a street or roadway in a residential neighborhood will need to be enhanced—from the public's viewpoint; most often this is achieved through landscaping, screening walls, careful design, or attention to details.

Landscaping. Suitable landscaping, along with proper planning of the substation arrangement and details will, in a large number of cases, fulfill the need for de-emphasizing the equipment and meeting the requirements for pleasant appearance. The plot plan, aided by advice from a person experienced in landscaping, should recognize topography, existing trees, other natural features, and the surroundings.

A number of general planting schemes may be followed for the landscaping. Some principal types are:

1. Diversion planting does not completely hide the substation but diverts attention from the equipment by creating one or more attractive "focal" areas, such as shrubbery groupings, specimen trees, expanse of lawn, or

Full text of conference paper CP 56-42 presented before a session of the AIEE Committee on Substations, AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956.

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Fig. 1. An example in which landscaping or other special treatment is not required by surrounding residents; the neat and well-kept appearance become distinct assets, however.

Fig. 2. An unpretentious landscaping job in which no attempt is made to hide the substation but rather to direct the eye to points of interest, such as the plantings at the center and at the left: also, note the minimum structure for the incoming line.

Fig. 3. An example in which ample background foliage tends to "absorb" the substation; the tall spruce trees in front of fence will fill-out and hide the transformer in a few years. Overhead line structure is as simple as possible, but by painting it a dark color it would be made less prominent.

Fig. 4. Partially depressing the substation equipment assists in almost completely screening it with reasonably tall evergreens. It is frequently necessary to achieve such an effect from the very start; such plantings approach the maximum size which it is practical to transplant.

combinations of these. Where it can be used, this scheme is usually preferred and the most attractive.

2. Complete screen planting attempts to fully hide the substation, or nearly so. Usually, this is employed where there are no overhead circuits or structures and it is necessary to entirely obscure the equipment. An attractive appearance may be more difficult to obtain with this plan.

3. Residential-type planting is used where the substation is in a building which fits in with the houses or buildings nearby. In this case, the planting is intended to tie the building to the ground, to enhance the looks of the place, and to harmonize with the surroundings.

4. Modest or partial planting is used where circumstances demand little or no landscaping, but where for good public relations it is desired to avoid the stark industrial look of an entirely unadorned substation. While this will apply mostly to stations in undeveloped areas, there will be instances where planting is optional in urban areas, such as declining residential sections, mixed residential–commercial streets, and "inside" locations—as a substation to the rear of a lot. Simple treatment will usually be quite effective for this type, such as a few groupings of common shrubs, trees if appropriate, and an ordinary lawn. This may be considered as similar, but plainer and less expensive than scheme *1*.

Landscaping done early, even before the equipment is installed, is often effective in avoiding unfavorable comments and objections based on false notions. Also, submitting landscaping plans to the local garden club or voluntarily conferring with the neighborhood association will develop a feeling of common interest and even pride on their part.

Screen Walls. Less often, more expensive measures than landscaping are required. This may be an ornamental wall along one or more sides, as a garden wall with ornamentation and landscaping. Or it may be walls to look like a building, but without roof and possibly without rear or side walls. In some instances, it has been necessary to erect a complete building to house the substation, making the building harmonize with those nearby, as a residence. It is believed, however, that such cases are relatively few in number and are becoming proportionately less.

Design. Improved appearance can also be realized through appropriate design of the substation and selection

A B C

Fig. 5. When is a substation not a substation?—When it's an attractive residence. An example of what can be done if it is necessary and justified by local conditions (A) front view from street; (B) cutaway view of interior; and (C) view from back.

of its equipment. Probably the most common application along this line is the "unit-type substation" with its streamlined equipment—usually just metal enclosed switchgear and transformer. As a rule, this is used with cables for the outgoing circuits, and when the supply is also in underground cables the streamlining is about complete. There are, of course, very many instances where this is not desirable or practical and switching structures are required.

Care in design can enhance the appearance; suggestions for this are: simplify the layout, keep the structure low, use steel rather than wood, and use a minimum number of members. Obviously, there are many combinations and variations of the foregoing, as well as other design features. One worthy of mention, which has been employed in a number of instances, is to depress the tall equipment—as the transformer and the tower, if any—by placing it in a pit. This has been used to permit screening behind a wall of reasonable height, for easier screening behind landscaping, or to secure uniform height with the switchgear for better over-all appearance.

Attention to Details. Many other measures have been used to render the substation less conspicuous and, thus, make it more acceptable in the neighborhood. One is to choose a paint color to blend with the surroundings and use it for the entire substation, including steelwork and fence. Ideas vary as to exact shade, but run through dark greys and quite a range of greens. Another measure is to omit the driveway, and in some cases even the walkway, to avoid carrying the eye from the street to the substation. Where a driveway must be provided, top it with fine gravel or dark stone rather than limestone chat or concrete. Then, by using grass generally within the substation yard and surfacing only a minimum area around the equipment with chat, concrete, or other white reflective material, it has been found that the enclosure does not "stand-out" and the industrial look is avoided.

Care in the placement of the equipment on the property can be important. Where practical, appearance may be helped by: putting its least obtrusive or "best-looking" side toward the street, as the end of the switchgear if a unit-type substation; by placing it as far back from the street as possible; or by locating it among or behind a grove of trees if present, etc.

Still other expedients are to "work on" the fence. Build it as low as is considered safe for the neighborhood, omit the barbed wires where safe to do so, or get away from the common chain-link fencing on iron pipes and use wrought iron or one of the many types of wood fences. These are suggested to further get away from the industrial look. In some instances the fence has been omitted entirely; with totally enclosed equipment having securely locked or fastened doors and covers, this rather bold step has been found satisfactory in appropriate instances.

While appearance from the public's standpoint is an increasingly important factor in substations located in residential areas, many distribution substations are located in nonresidential locations and to them these remarks do not necessarily apply.

NOISE

Requirements To Satisfy Neighbors. Just as appearance, noise from a substation must also be acceptable to nearby residents. But it is usually less practical to anticipate their reactions or, for that matter, to know with certainty just what the sound level will be at the trouble spot—invariably the neighbor's bedroom window—so the noise problem, when present at all, is usually acute and difficult to cope with.

Because this report is concerned with substations in residential districts, the daytime ambient sound level of the neighborhood is not as much of a factor as might at first be expected. When complaints of substation noise are registered by nearby residents, they usually contend that they are bothered at night—that intermittent overriding sounds are not as disturbing, however, as the unceasing "hum" of the transformers.

The ideal condition is that the transformer be completely inaudible. This is a stringent requirement, for the transformer component of the sound at the point of complaint would have to be lower than the ambient. Experience has shown, however, that in most cases the transformer does not have to be entirely inaudible; its sound will be acceptable if it is about equal to or even slightly above the ambient at the point of complaint. This is offered as a probability, not as a positive formula, for it is not believed that one is possible. The problem involves as much, or more, personal psychology and human relations as engineering, and a satisfactory condition in one instance may be unacceptable in another.

How to Treat the Problem. The noise problem may be dealt with in different ways: (1) When it can be anticipated, special design or equipment may be employed to avoid it; (2) In choosing the substation site, the possibility of noise complaints is an important factor to be considered and may well be the deciding one; (3) In planning the layout on the lot, it will be wise to place the transformer as far as possible from nearby residences; (4) If necessary, the sound can be confined or absorbed; and (5) In some instances it may be expedient to "take a chance" on it and hope for the best, providing there is a practical way out should corrective measures be necessary later on.

In any event, to mitigate the noise usually costs real money. This will be treated under two general categories: (1) using "quiet" equipment; and (2) confining or absorbing the sound.

Quiet Equipment. Use of quiet transformers, as well as other equipment, are a matter of economics. Frequently standard transformers turn out to be of lower sound level than prescribed by National Electrical Manufacturers Association limits but, of course, this is not assured or guaranteed. Transformers guaranteed of lower than standard level are available at increased cost, but with the steps of sound-level reduction being relatively small and at cost increments which become disproportionate for appreciable sound reductions. So the need for the lower sound must be weighed against its cost. This decision is made difficult by the knowledge that a standard transformer might turn out to be more quiet than prescribed. The problem is further complicated by not knowing what the noise level must be; i.e., being unable to predict just what over-all sound level will be acceptable to the nearby residents. These latter considerations lead to investigation of other measures, which will often be found preferable.

While rarely possible, there have been cases where "swapping" transformers gave a quiet one where needed. For example, two quiet transformers which happened to be in a substation in an industrial district were interchanged with two noisy ones at a substation with a noise problem, after which "everything was lovely." Obviously, such possibilities are few, but the idea is mentioned as worth further checking.

It should go without saying, of course, that upon learning of a noise problem after installation, the first thing to do is to thoroughly check the transformer and other equipment in the substation for vibrations and rattles of accessories, conduits, radiators, etc. Such sounds have been known to be the cause for the noise complaint; usually they are easily damped or eliminated.

Containing the Sound. Any discussion of the means of confining or absorbing the sound should also explain the nature of transformer sound. As is known, it results from magnetostriction of the core iron which, for 60-cycle voltage, occurs 120 times per second. The total sound from a transformer is comprised of 120-cycle frequency tones and many harmonics, but usually with 120 or 360 cycles the strongest. This means long wavelengths, which are the most difficult to intercept or absorb. To completely analyze the pattern, to predict the attenuation of the various harmonics, and to specify the type of materials and design of structure to accomplish the required sound reduction becomes a very technical problem, mostly in physics.

Fortunately, such a rigorous approach is not required, except possibly for the extra troublesome cases. In most instances, an analysis of the conditions and some general engineering knowledge of the subject are sufficient.

Sound is usually controlled in one of two general ways—by confinement, or by absorption. For the first one, mass is needed and generally a bit of extra size, because there is a tendency for sound to spill over the top and around the open ends of confining barriers; for the second one, a porous material is needed—and the lighter and thicker it is the more effective for the low frequencies to be absorbed. Sound barriers utilize one or both principles.

No attempt has been made to study all of the many kinds of sound barriers, which might be applied, or to determine the amount of reduction to be expected from them. Rather, typical examples are described, ranging from very simple ones for slight reduction to quite elaborate ones for considerable improvement. All of these are assumed to be vertical barriers, which are mounted independently of the transformer, and of such dimensions and enclosing such sides of the transformer as conditions warrant, as discussed later.

Sound Barriers. Typical barriers that may be used are:

1. Masonry wall of concrete blocks, bricks, poured concrete, or other materials; reinforced as required (Fig. 7*A*).

2. Same as *1*, except with inclined canopy toward and possibly partially over transformer; canopy of asbestos lumber or corrugated metal with underside lined with acoustic ceiling-type tiles treated for weather and fire resistance (Fig. 7*B*).

3. Structural steel frame on which are mounted sound absorbent panels, consisting of sheet metal pans filled with fiber glass treated for weather resistance and retained in place by hardware cloth on the face toward the transformer; thickness and density can be varied (Fig. 7*C*).

4. Double masonry wall with 2- to 6-inch space between; space to be dead air or filled with heat insulating material such as fiber glass, rock wool, vermiculite, or other. When such walls are used it is usually with a complete or partial roof or with the walls extending appreciably above the transformer to intercept the "spill" (Fig. 7*D*).

5. Combine *3* with *1;* i.e., sound-absorbent panels mounted on the transformer side of masonry walls (Fig. 7*E*).

6. An elaboration of *5* wherein the sound absorbent material is 6-inches thick, of chosen density, and mounted with a 12-inch air space between it and the masonry. The air space is divided vertically by thin sheets spaced according to the wavelength of the prevailing frequency.

Barriers of the latter design were built around two 100,000-kva transformers in a transmission substation and corrected a serious noise problem.

The location, extent, and size of the barriers are of im-

portance, too. Following are a few general rules for overall guidance:

1. The barriers should be as close as practical to the transformer. Space must be allowed, of course, for ventilation, operation, and maintenance; while theoretically possible to get them too close, practical considerations normally preclude that. They should extend to the ground except in very special cases.

2. They should be higher than the transformer, if possible; the height depending upon the distance from the transformer and the distance to the complaint (sound waves travel in great arcs).

3. If the trouble spots are in only one direction from the transformer, the barrier should be on that side of the transformer plus full or, at least, partial barriers on the two right-angle sides. If there are residences close by in several directions, a 4-sided enclosure, or nearly so, may be required.

4. Ventilation must be considered if the barriers surround the transformer; this may lead to placing the barriers farther from the unit than noise considerations alone would dictate. Auxiliary fans can be used if necessary.

5. If the enclosure is less than complete (three sides or less), increased sound in the direction of the open end may be encountered; also, sound reflection may occur from buildings or other equipment in the direction of the open end.

6. Descriptions of devices which emit counter frequencies to largely cancel the transformer sound have appeared in the press, but the authors of this report lack experience on these at this time.

7. Outdoor switchgear might be counted upon as an effective sound barrier in the direction it is situated and to the extent it embraces the transformer. The same is true of buildings, if any, in the substation.

8. Trees or shrubbery have no measurable effect in blocking or absorbing transformer sound.

In some instances it may be a good plan to omit corrective measures from the original installation, but allow for them in the basic design so they can be added later if found necessary. With the great number of variables and unpredictables involved, there is often the possibility that after going in service it is found that nothing special is needed.

Fig. 6. The "last word" in beautifying a substation. The principal part of this station is unroofed and its walls are of precast construction.

ZONING

In considering residential areas only, it follows almost automatically that substations are not welcome, as general zoning restrictions are intended to permit only residential construction in such areas. As a rule, the admission of substations will be through special dispensation of one form or another. Therefore, this discussion of the subject of zoning will concern such dispensation or, in other words, what is involved in obtaining the permit to build the substation?

Obviously, regulations and laws vary in different cities and states so the best approach will depend upon the local situation. Some ways of dealing with the problem and factors to be considered are:

1. Variance Permit. Apply to the appropriate local officer or board for a variance (or use) permit which, in effect, is a request to use the property because of the public-service nature of the substation. Frequently, the permit is granted forthwith, or after "routine" consideration. When delayed, the request will often involve a public hearing and will probably entail a carefully prepared presentation. Some cities require that all property owners within a stated distance be personally contacted and their agreement or disagreement reported to the authority having jurisdiction. This provides an opportunity to thoroughly and individually explain the project.

If granted, the permit will frequently contain special features to which the applicant has agreed, such as preserving existing trees or shrubbery, submitting landscaping plans for approval, specifying type of fencing or driveway, and including the presence or absence of overhead structure, etc.

Many utilities prefer this plan as being the least formal, most likely to preserve good public relations, and usually encountering the least delays.

2. Rezone. Approach the legislative body of the municipality, requesting that the proposed location be rezoned for the proposed use. This is almost certain to call for a public hearing, and may not be essentially different from that of point *1*, except that it is before a legislative rather than an administrative body. This form of request will usually be the next step if an initial request, as under point *1*, is denied and for that reason some companies prefer it as the first approach.

3. Utility Exempt. The utility might claim that it is not subject to zoning ordinances which hamper its rendering adequate service and might employ court action to force the issuance of the permit. All will agree that this method is not desirable, except possibly as a test case for use in pressing other cases at a later date.

4. Site Exempt. Appeal to the state's utilities commission to exempt the proposed site from the local zoning ordinance, where such statutory provisions exist. This also involves a public hearing, a carefully presented case, and personal contacts of nearby residents are usually advisable. Some utilities (in states where applicable) have followed this course with reasonable success.

5. Revise Ordinances. As a long-range approach, it has been suggested that endeavors be made to obtain revision of zoning ordinances, so as to establish clearly the right of a

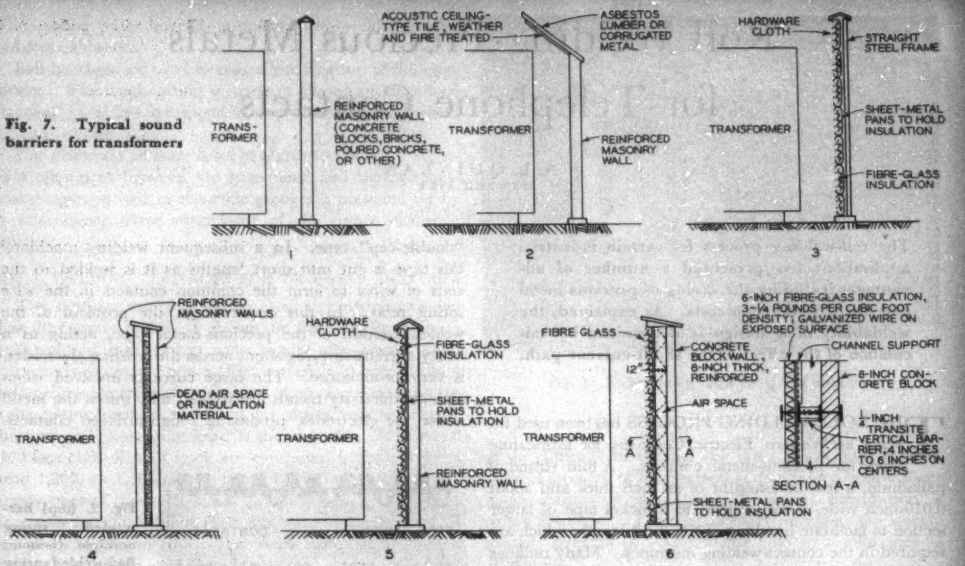

Fig. 7. Typical sound barriers for transformers

public utility to install equipment in locations where needed, subject to appropriate regulation as to the manner of so doing. The installation permit would then be granted by an administrative officer, subject to such reasonable regulatory provisions as necessary for adequate protection of the community. This procedure would eliminate the troublesome public hearings needlessly arousing ill-founded opposition, and would avoid legislative and legal delays presently impeding necessary projects.

Related to this is a plan now being followed or recommended in many newly developed areas whereby the subdivisions are platted with space allotted for necessary utilities. It should be the responsibility of the subdivision developer to consult the utility on this point.

Meeting or Avoiding Objections. It is to be admitted that, in many instances, appearance or noise, or both, will be of concern to surrounding residents or local authorities, and appropriate measures must be employed to make those acceptable. Usually, this will involve some of the expedients covered in the foregoing sections. Unless they become too elaborate, it will usually be preferable to employ them than to relocate the substation at a site less desirable from a transmission and distribution standpoint.

Of course, if an alternate location of nonresidential character is available, it should be used, providing it is favorable to economic and system conditions. If the alternate is industrial in character, there should be no zoning problem. If commercial, there may still be troubles because of restrictions, depending upon the type of the commercial area and the attitude of its occupants. Objections will usually be easier to overcome than in residential areas, although the satisfying measures, as well as the property costs, will probably be much more expensive.

There have been instances where objections of potential neighbors were overcome and "variance permits" obtained by placing the substation toward the rear of the property, especially where the lot was quite deep. Then after reserving a driveway strip, the front of the lot was sold and built upon, resulting in the substation being effectively screened. These may be unusual or fortunate cases, but the idea is something to bear in mind in selecting sites.

Another method which has been used and has received considerable publicity is to comply with residential requirements; i.e., to enclose the substation in a building to harmonize with the surrounding residences, making the substation look like an attractive residence. This method has been very effective where local conditions required and company policies permitted its use.

As stated, the best approach for obtaining permits under zoning and other legal restrictions will differ with local conditions and laws, system economics, and company policies. The foregoing is simply to call attention to many of the alternative means which can be employed.

GOOD PUBLIC RELATIONS

In conclusion, it is repeated that for substations in residential areas special attention should be given to appearance and noise to obtain acceptance by surrounding residents. Through this means it is believed that the public's opinion of a substation will gradually change from an unfavorable one, as exists in many quarters today, to a favorable one in the future. Furthermore, such improvement will be reflected in other aspects of customer relations and in the over-all sentiment of the public toward the electrical utility serving them.

Roll Welding Precious Metals for Telephone Contacts

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MEMBER AIEE

The roll-welding process for certain industrial applications has presented a number of advantages including the saving of precious metal and lower production costs. As explained, the weldability of a design is determined by calculation of the effect of the shunt-current path.

THE ROLL-WELDING PROCESS has been used for years at Western Electric Company for fabricating tapes for precious-metal contacts. A thin strand of palladium, a few thousandths of an inch thick and about 0.010-inch wide, is roll welded to a nickel tape of larger section to facilitate handling of the short lengths which are required in the contact-welding machines. Many millions of contacts are needed in the telephone equipment manufactured each year, so that many contact welders are in use.

Several years ago, a special roll-welding machine was developed to reduce the contact-welding cost on crossbar switches. With this machine, the contact tape is roll welded to strip stock for springs before they are blanked from the stock. This has proved to be the most economical method of producing the precious-metal contacts.

More recently, the introduction of the Bell System's wire spring relay has required the roll welding of much heavier precious-metal tapes. Palladium, 0.010-inch thick and 0.042-inch wide, must be welded to opposite edges of a cupro-nickel base section, 0.042 by 0.079 inch, to make a "double-cap" tape. In a subsequent welding machine,[1] this tape is cut into short lengths as it is welded to the ends of wires to form the common contacts in the wire spring relay. In this construction, the problem of the welded portion of the precious-metal tape, acting as a heavy current-carrying shunt across the welding electrodes, is very pronounced. The large currents involved when high-conductivity metals are welded may soften the metal under the electrodes, producing rough-surfaced contacts.

Fig. 1. Roll welder for double-cap tape

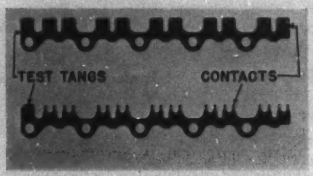

Fig. 2. (top) Bar-welded spring multiple. (bottom) Roll-welded spring multiple

A method of calculating the relative importance of the current in the short circuit, as compared to the weld current, has been developed. This method may be used for evaluating design features such as metals used, weld spacings, and dimensional changes, before building a welder.

ROLL WELDERS

THE ROLL WELDERS are substantially the same for each of the jobs described, i.e., welding contact tape to flat stock for blanking spring multiples, and welding the heavy sections of contact tape for wire relays. The details for guiding the stock may be varied. The welder line, shown in Fig. 1 for heavy contact tapes, is typical. The base strand is pulled through the machine by a roll puller, located just out of the picture to the right. The speed of the tape through the line is chosen so the 60-cycle weld energy with pulse peaks 1/120 second apart will be spaced along the tape at the best intervals for adequate strength. The strip is degreased, wire brushed, welded, rolled in a sizing mill, and coiled on a reel. Electronic heat control is provided, which sharpens the rise rate of the current pulses and holds constant the power applied to the weld zone. Voltage-drop brushes on the electrodes and a current transformer in the weld circuit furnish a signal to the control unit. This unit holds the power at any setting up to 1.5 kw regardless of variations in circuit resistance or line voltage.

Full text of paper 55-762, "Roll Welding Precious Metals for Telephone Contacts," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3-7, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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The cooling water liberally supplied to the weld zone also reduces oxidation.

Ball bearings are used to assure free rotation of the electrodes. The head casting is made of aluminum to reduce its mass. It is free to respond in a vertical direction, guided in ball-bearing ways.

The electrode pressure is set at about 40 pounds. Accurate alignment between the base-metal and the precious-metal tapes carried in electrode grooves is provided for by a micrometer axial adjustment of the upper electrode head.

ROLL WELDING CONTACTS FOR CROSSBAR SWITCHES

THE COMMON MULTIPLE SPRING used in crossbar switches has 20 contact points, as shown in Fig. 2. Previous to roll welding, the springs were made with broad tangs carrying two contact points (Fig. 2, top). In order to nest two springs for the economical use of precious metal by the roll-welding method, the tangs are made narrow (Fig. 2, bottom). The welding head is shown in Fig. 3. Several 200-foot coils of strip stock are connected by butt brazing into 1,200- to 1,500-foot coils before roll welding to avoid many stops of the welding line for rethreading. The take-up reels for the welded coils are made large enough in diameter to prevent the coiled stock from taking a permanent set, which would result in bowed parts. The welding line, shown in Fig. 4, operates at about 1,200 feet per hour.

The blanking tool, shown in Fig. 5, is of the multistage type: (1) a short length of the tape from the portion of the stock used for the large test tang, which must not have a contact, is sheared off; (2) the precious metal between the tangs, which is not required, is removed; and (3) the blanking is completed, freeing the two spring multiples with all contacts in place.

Because all length dimensions including contact lengths are determined by the die and, therefore, can be held much more accurately than when welded by the previous individual contact welders, a 20-per-cent reduction in contact length with resulting precious-metal saving is realized. Also, the effectiveness of cleaning operations in the line makes it possible to use a less expensive brass strip stock instead of nickel silver. Previous attempts to make this change prior to roll welding were unsuccessful, because

Fig. 3. Roll-welding head for spring multiples

of the difficulty of keeping the brass bright until welded.

Weld strength of the contacts is determined with a shear gauge, calibrated in pounds. A typical distribution is shown in Fig. 6. For control-chart purposes, the weekly average strength of -4σ is being held to a minimum of 20 pounds.

DOUBLE-CAP TAPE

THE GENERAL CONSTRUCTION and dimensions of double-cap tape are shown in Fig. 7. The cap metal is normally palladium and the base metal is cupro-nickel (70–30 per cent). The 0.101-inch dimension between the cap surfaces must be held to close limits as it enters into the limits between "make" and "break" contacts of the finished relay. Also, close limits are necessary to permit ready handling in the automatic percussion welder, which cuts contact lengths from this tape and welds them to the ends of the wires in the wire spring relay.[1] The precious-metal tapes for the top and bottom sections are formed with weld beads on the surface to be welded. Weld beads concentrate the weld heat in a reduced section, thus facilitating welding by requiring less power. Fig. 7 shows the tape divided into sections or blocks, corresponding in length to the space traversed by the welder during each half cycle

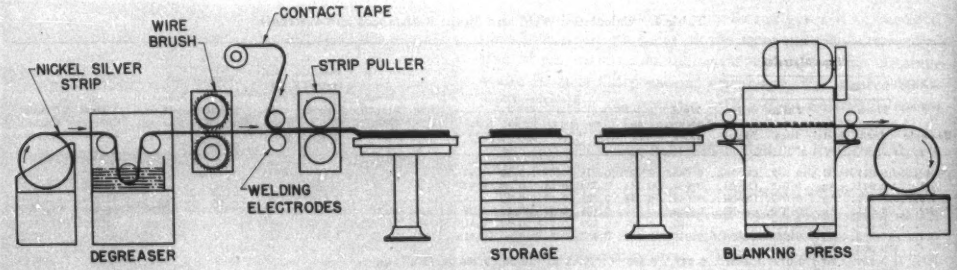

Fig. 4. Roll-welding line

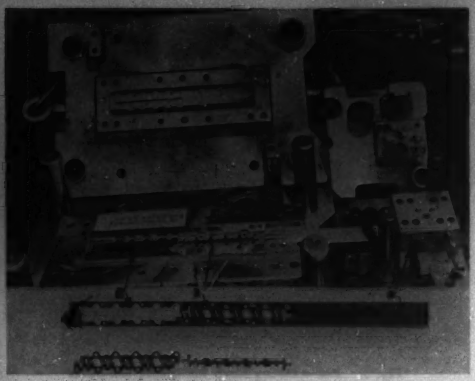

Fig. 5. Blanking die for roll-welded multiples. *a—shearing tape from test lug; b—removing extra contact tape; c—completing the blanking of two multiples*

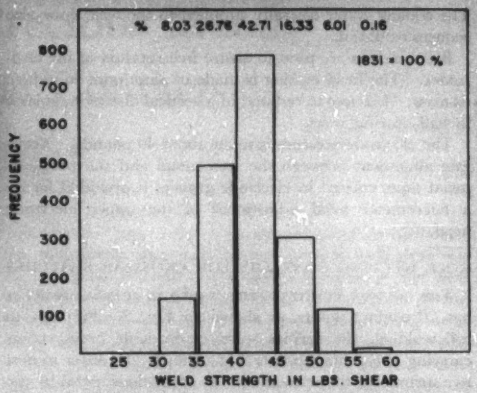

Fig. 6. A typical distribution of the weld strength of roll-welded multiple contacts

of the 60-cycle power used for welding. These block elements are used in the shunt-resistance calculations to be discussed later.

The welder for this double-cap tape is equipped to feed cap metal simultaneously into grooves in both top and bottom electrodes. The base-metal strip is guided in a slot to enter the space between the electrodes. This guide, as well as the bottom electrode, is electrically insulated from the upper electrode. Since the welds are made in series, close control of the heat loss from the electrodes through conduction paths and through the cooling water must be obtained to balance the weld strength in the top and bottom welds. A typical weld shear strength for an 0.083-inch length of cap weld is 50 pounds.

CALCULATION OF SHUNT RESISTANCE

THE AMOUNT OF CURRENT which can be conducted into the metal without burning the electrodes or the tape surfaces is limited; the high-conductivity metals already discussed require currents close to this limit. It is desirable, therefore, to be able to determine in advance what tape designs or modifications can be welded. A method has been worked out for computing the resistance of the direct path between the electrodes as compared to the shunt path, the one through the "just welded" portion of the tape. The high conductivity of these metals makes the shunt-current path very important, as will be shown. The area trailing the weld zone (Fig. 7) is red hot because of successive pulses of shunt current. Fig. 7 shows the tape, the schematic circuits, and the equations for the branch resistance. Inasmuch as the electrode contact resistances r_5 are common to both weld and shunt paths, they have been omitted from the calculations. Also, the resistance of transverse sections of the cap metal r_6 are small and have been omitted. There are, of course, other omissions and simplifications; for instance, the current distribution paths through and between segments are unknown, but are assumed to be uniform. Table I, which was calculated from the equations, shows the per cent of current going through the shunt path for different conditions of weld spacing and materials.

The resistance elements of the shunt path are calculated from the specific resistivity of the weld metals and the dimensions of the circuit elements. For instance,

Table I. Calculated Weld and Shunt Resistances and Currents

Example	Tape Material: Cap Thickness, Inch	Cap Metal	Base Thickness, Inch	Base Metal	Weld Spacing, Inch	Resistance, Ohms: r_1 ×10⁻³	r_2 ×10⁻³	r_3 ×10⁻³	r_4 ×10⁻³	$r_1{}^2$ ×10⁻⁴	$4r_1$ ×10⁻³	Weld Branch, Ohms ×10⁻³	Resistance of Shunt Branch, Ohms ×10⁻³	Total Resistance, Ohms ×10⁻³	Shunt Current, Per Cent	Estimated Weld Current, Amperes	Total Current, Amperes	Shunt Current Amperes
A	0.011	Pd	0.079	Cu–Ni	0.045	2.22	0.725	0.61	0.30	4.93	8.88	1.21	2.795	0.845	30.3	812	1,165	353
B1	0.011	Ag	0.079	Cu–Ni	0.031	0.165	0.725	0.61	0.30	0.027	0.660	1.21	0.437	0.320	73.2	1,200	4,480	3,280
B2	0.011	Ag	0.079	Cu–Ni	0.045	0.248	0.725	0.61	0.30	0.062	0.992	1.21	0.566	0.387	68.5	1,200	3,810	2,610
B3	0.011	Ag	0.079	Cu–Ni	0.062	0.330	0.725	0.61	0.30	1.09	1.320	1.21	0.88	0.510	57.8	1,200	2,850	1,650
B4	0.005	Ag	0.089	Ni	0.060	0.644	0.920	0.171	0.30	0.415	2.58	0.771	1.157	0.462	40.2	1,200	2,010	810
B5	0.005	Ag	0.089	Cu–Ni	0.060	0.644	0.967	0.81	0.30	0.415	2.58	1.41	1.174	0.639	54.7	1,200	2,650	1,450
C1	0.002 + 0.009 + 0.002	Ag + Pd + Ag	0.079	Cu–Ni	0.045	0.535	0.725	0.61	0.30	0.286	2.14	1.21	0.944	0.531	53.4	812	1,730	918
C2	0.002 + 0.009	Ag + Pd	0.079	Ni	0.045	0.535	0.697	0.202	0.30	0.286	2.14	0.802	0.933	0.433	46.1	812	1,510	698

example *A*, Table I, shows the resistance r_1 calculated for two pieces of palladium, each 0.011- by 0.042-inch in cross section and one weld spacing (0.045-inch) in length, one piece at top and one at bottom, at a temperature of 500 F. The resistance r_2, which completes the first shunt path, is calculated for the base-metal cross section, 0.042-by 0.045-inch and 0.079-inch long, at 1,200 F, its estimated operating temperature. As indicated in the circuit of Fig. 7, the summation of all these shunt paths, each of which represents a weld stitch, is symbolized by R_s. Example *A* shows a power loss of 30.6 per cent through the shunt path. Judged from experience, welds can be made satisfactorily under these conditions. The conditions represented by example C_1 have been welded, but are considered to represent limiting conditions with a power loss of 53.4 per cent. A change to the use of nickel-base material, as shown by example C_2, would improve weldability, as the loss is only 46.1 per cent. Changes to improve the weldability of a silver-capped tape, where the loss is brought down from unweldable 73.2 per cent to 40.2 per cent, are shown as B_1 to B_4 in the table. In this way, an advance picture of weldability can be obtained.

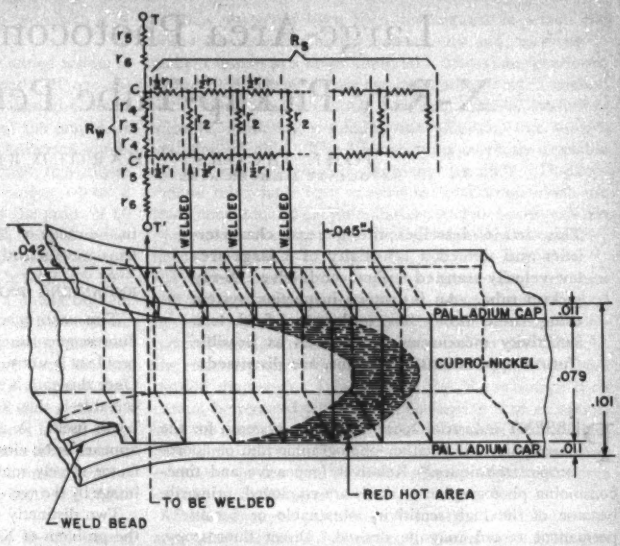

Fig. 7. Double-cap tape and resistance circuit, showing segments used in calculating resistances of elements for computing weldability (Table I)

$R_{TT'}$—Resistance between electrodes; $R_{CC'}$—Calculated resistance $= R_W R_S/(R_W+R_S)$; R_W—Resistance through weld zones $= 2r_4+r_3$; R_S—Resistance of shunt paths $= 7/2(r_1+\sqrt{r_1^2+4r_1r_2})$; r_1—Cap resistance, top and bottom segments at 500 F; r_2—Resistance of basemetal segment at 1,200 F; r_3—Resistance of basemetal segment at 75 F; r_4—Contact resistance, cap to base, measured; r_5—Electrode contact resistance; and r_6—Transverse cap resistance.

CONCLUSIONS

THE ROLL-WELDING and blanking method of making multiple contact springs has resulted in considerable economy in use of precious metal and in the production of contacts at a reduction in cost. Lower cost base materials are used because of the thorough cleaning closely associated with the welding.

Roll welding, although difficult on high-conductivity metals, can be used to advantage on many applications. A calculation of the effect of the shunt path is desirable to predetermine the weldability of a design.

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Gas Turbines Pump Gas at Lake Maracaibo, Venezuela

Three-hundred-million cubic feet of gas will be pumped back into the earth daily by the most powerful concentration of gas turbines in the world. Built by the Westinghouse Electric Corporation, Pittsburgh, Pa., twelve 8000-hp combustion gas turbines with a total maximum rating of 96,000 hp will be installed 7 miles out on Lake Maracaibo, Venezuela, on a platform, 440-feet long by 131-feet wide, mounted on concrete piling in 80 feet of water. They will drive centrifugal compressors which will inject natural gas, derived from oil operations, under high pressure into the oil field that is under Lake Maracaibo and the surrounding area. This gas conservation plant will recover substantial quantities of additional petroleum, as well as conserve large quantities of gas.

Large-Area Photoconductive X-Ray Pickup-Tube Performance

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HAROLD BERGER

This article describes the general characteristics and detection sensitivity of a large-area low-velocity-scanned photoconductive X-ray pickup tube. An industrial inspection system using these tubes has undergone field test. Sensitivity measurements, as well as possible future applications of systems, are discussed.

PRESENT industrial X-ray inspection systems, for the most part, utilize either photographic film or fluoroscopic techniques.[1] Relatively expensive and time-consuming photographic methods are employed, primarily because of the high sensitivity obtainable or because a permanent record may be desired. Direct fluoroscopy, which is comparatively fast and inexpensive, is in widespread use despite certain disadvantages. These include the need for dark adaptation, somewhat lower sensitivity than film, radiation shielding, and health physics problems.

At voltages in excess of 140 kv peak, many factors limit the use of direct fluoroscopy. The first of these is that of operator protection. Protection problems are greatly simplified if the geometry of the viewing screen is arranged in such a manner that the operator views the image through a mirror system. In this way, the protective window is not exposed and, hence, not deteriorated by strong irradiation. However, such a geometry has the disadvantage that the operator is usually set back from the viewing screen to a point where visual acuity of the eye limits the amount of small detail that is discernible. The problem of visual acuity is further complicated by the low light levels encountered in direct fluoroscopy, these being in the order of 0.1 foot-candle or less.

In addition to the above limitations to the vision of the operator, the fluorescent screen itself decreases in response at the higher voltages. The contrast sensitivity of the screen is decreased markedly at high voltages by the increase of relatively low-energy scatter from the objects being inspected. Screen particle size, usually in the order of 1 mm, further limits the detail sensitivity of the direct fluoroscopic system. In spite of these disadvantages, at voltages in the range of 20 to 100 kv peak, many inspection problems are efficiently handled by a direct fluoroscopic system.

Text of conference paper CP56-23 presented before the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956, and recommended for publication by the Committee on Electrical Techniques in Medicine and Biology, and the Subcommittee on Industrial X-rays of the Committee on Electronics.

John Jacobs and Harold Berger are with the General Electric Company, Milwaukee, Wis.

Grateful acknowledgment is made to Rudolf Prerichs of the Physics Department, Northwestern University, Chicago, Ill., who in his role as consultant on photoconductors to the X-ray department, has rendered immeasurable service to us; and our sincerest thanks to P. E. Paschier, J. R. Eshbach, R. W. Redington, and R. W. Damon of the General Electric Research Laboratory for the many measurements and stimulating discussions throughout this development.

ENHANCING BRIGHTNESS OF FLUOROSCOPIC IMAGE

THE NEED FOR AN INCREASE IN BRIGHTNESS of the X-ray fluoroscopic image has long been recognized.[2] This problem is unusual in that a minimum gain is sufficient.[3] Once this gain is exceeded, the limitation in information receivable is then set by the quantized nature of the X-ray beam itself. A general figure for this gain in sensitivity appears to be close to 100 times. Any increase above this factor merely makes for more comfortable viewing of the image by the eye.

Two distinctly different approaches have been made to the problem of X-ray image intensification. One of these is the application of direct-image converter tubes to the X-ray problem.[4,5] The other is the use of television or electronic scanning methods.[6,7,8,9] The first results in an extremely simple system requiring only the image tube and a power supply. The second method requires electronic amplification and is rather complicated compared to the first one. Both approaches are capable of supplying sufficient gain so that the information contained in the X-ray quanta itself becomes the limiting factor.

It is with the scanned-pickup-tube approach (Fig. 1) that this article is concerned. The first approach has been discussed extensively during the past 7 years of commercial application.

CONSIDERATION OF SCANNED-IMAGE SYSTEMS

THE USE OF THE SCANNING TECHNIQUE for the presentation of images instead of the direct-viewing method gives rise to many features of basic design of which the average user of fluoroscopic systems is generally unaware. For a scanning system to be a successful and simple one, it should contain in the pickup tube a storage element. This is dictated by the fact that if an image consists of 500,000 elements the beam scans one element of the image for only 1/500,000 of the time needed to scan the complete image. The remaining period of time the scanning beam is essentially commutating the other 499,999 elements of the picture. This means that in the absence of a storage element in the sensitive surface only the information produced on the element during the scanned interval is utilized. By arranging the system in such a manner that an element accumulates information during the entire period between scans, the sensitivity of the system with storage may be increased by a factor of 500,000 times over that of one without. This is well known in camera-tube practice.[10] In the case of the direct-image-converter

systems, a storage factor is supplied by the eye which is in the order of 0.1 second.

Another feature to be considered in a scanned system is the amount of detail that may be obtained. If one assumes an infinitely fine scanning beam, then the detail transmitted is limited by the bandwidth of the amplifiers in the system. Using for convenience the American standard of 525 lines interlaced 30 frames per second, then allowing for retrace and blanking, the time during which a horizontal line of the image is active is in the order of 50 microseconds. Utilizing readily available television circuitry having a bandpass to 8 mc, one could therefore read out of one horizontal scanned line $2\times8\times10^{6}\times50\times10^{-6}$ or 800 distinct elements. The factor of 2 enters because one cycle of a sine wave presents two bits of information. As far as the system is concerned, then, assuming the scanning tube is not the limiting factor, any horizontal line can contain 800 distinct picture elements. This means that if the pickup tube has a horizontal scanned dimension of 8 inches the smallest detail that can be resolved is 0.01 inch. However, if the scan width on the same tube is reduced to cover a region of 1 inch, then assuming the scanning beam is infinitely fine, the detail resolvable would become 0.00125 inch.

In the tubes discussed in this article only the first stated case may be approached, principally because of the finite size of the scanning beam. This practical limitation as it exists in the present tubes will be discussed in the next section.

LOW-VELOCITY-SCANNED PHOTOCONDUCTIVE TUBES

THE IDEA for the use of photoconductive layers for television pickup tubes was advanced in 1908.[11] A demonstration using this type tube was made in England in 1938.[12] The widespread commercial use of this principle of pickup tubes did not occur until the early part of the 1950's.[13]

The tubes using these principles are being used in increasing numbers by commercial broadcasters to replace the iconoscope in film transmission. At the latest report, the Vidicon, as the commercial version of this tube has been termed, is only 10 times less sensitive than the image orthicon, the standard studio camera tube. This rapid commercial utilization of the photoconductive pickup tube came about largely because of a better understanding of both the photoconductive process and synthesis of photoconductive material.

For a photoconductor to function properly as a layer in a storing-light pickup tube it must, in addition to having good photosensitivity, have a dark resistance in the range of 10^{12} ohm-centimeters. If the resistance is less than this, a serious loss in available signal occurs as the charge leaks off between scans and the storage effect previously mentioned is not fully utilized. Fortunately, in the case of tubes designed for X-ray service, thick layers are desired to assure an adequate absorption of the X radiation. The loss in capacity of the target because of the increased thickness of the layer is offset to some extent by the increased area of the picture elements in these large photoconductive X-ray tubes.

Many materials have been investigated in which the photoconductor has both the sensitivity and resistivity to make it usable as a target material. Materials, mentioned in the 1938 article[12] as giving signal outputs when excited with light, are selenium, cadmium sulfide, cadmium selenide, antimony trisulfide, zinc telluride, zinc sulfide, and zinc selenide. The Vidicon tubes currently available in this country employ antimony trisulfide. Developmental tubes have been constructed in Europe which use lead monoxide. That the sulfurized lead monoxide exhibits photoconductivity and has the desired values of resistivity needed for camera-tube operation was noted in 1949.[14]

Photoconductive X-ray pickup tubes using selenium and lead monoxide as target materials have been described in recent years.[5,9] The principal disadvantage from a commercial standpoint of the tubes described to date has been the relatively small size of the sensitive area (less than 2-cm outside diameter). Inasmuch as the X-ray image itself cannot be reduced without first converting it to an optical one, the need then in a direct conversion tube is for a large-area signal plate. The tubes evaluated and those being evaluated in the field have an effective signal-plate area over 18 cm in diameter.

Such large-area plates operated with a 30° low-velocity scan place rather stringent requirements on the electron guns. To assure stabilization and to simplify associated circuitry, thus, electrostatic scanning is used. The spot size of the guns is in the order of 0.25 mm and is the limiting factor in detail resolution along the horizontal scan. Until such time as better guns are available there appears to be no need to depart from the 525-line standard currently in use.

CONSTRUCTION OF PICKUP TUBES

CONSTRUCTION TECHNIQUES used in the tubes are different in that the photoconductive layer is prepared and tested prior to sealing into the tube.

A lead monoxide layer approximately 150-microns thick is evaporated onto the aluminum signal plate in a standard bell jar. The plate is then removed, and placed in a demountable scanning tube and checked for blemishes, sensitivity, and speed of response. If acceptable, the layer thus prepared is sealed into an envelope. This method of

Fig. 1. Large-area photoconductive X-ray pickup tube; dark coating necessary to exclude light

assembly avoids the extremely difficult job of forming the large-area layers in a completed tube assembly. To assure maximum sensitivity of the tube, the face plate should be as thin as possible. Currently, a thickness of 2 mm is used. To assure that implosions caused by thin sections or residual strain will not occur, each tube following exhaust is placed in a pressure chamber under three atmospheres for a period of 10 minutes.

Currently, all tubes are being run in for 100 hours after processing to assure that any residual gas in the layer evolves and is picked up by the getters. Life experience to date indicates unlimited shelf life and operating life well in excess of 1,000 hours. Actually, the only cause of failure of the tubes has been a loss of emission of the filaments. Since the layers are relatively insensitive to the atmosphere several tubes which lost emission have been regunned and are currently giving satisfactory service.

X-RAY SENSITIVITY OF LAYERS

MEASUREMENTS MADE on the tubes constructed to date indicate that on the average for each quantum of X radiation absorbed in the layer, approximately 1,200 electrons are detectable in the external circuit. The energy of the X radiation used for these measurements was 43-kv peak, effective. The tube current was 0.25 milliampere and the distance was 60 cm.

Using an input impedance of 5×10^{4} ohms at the video preamplifier, the noise current produced by this resistance is approximately 1×10^{-9} ampere. Taking as a minimum acceptable signal-to-noise ratio the figure of 5, then a current of 5×10^{-9} ampere is the minimum signal recognizable. By absorption measurements at the conditions cited, it has been determined that approximately 25 per cent of the incident energy is absorbed in the layer. This means then that the minimum number of detectable quanta per second incident on the entire plate is

$$N=\frac{4\times5\times10^{-9}}{1200\times1.6\times10^{-19}}=\frac{20\times10^{-9}}{2\times10^{-16}}=1.0\times10^{8}$$

Fig. 2. Field test unit in operation showing thermal units being inspected on conveyor; magnified image of unit on screen

Fig. 3. Quality-control personnel tabulating a sample run at remote viewing station

The effective area of the plates is approximately 300 sq. cm; therefore, the incident intensity at the wavelength cited to produce a usable signal is in the order of $1\times10^{8}/3\times10^{2}$ or 3×10^{6} quanta per sq. cm per sec.

RESULTS OF FIELD EVALUATION

TO DATE, the only field test data available covers industrial installations (Figs 2 and 3). The image system is used in applications where, because of the nature of the product, direct fluoroscopy fails to present fully the information available in the X-ray beam, principally because operator-protection devices and the low-screen-light levels are involved. A customer who was carefully selected had the following requirements: (1) utilizing fluoroscopy at least 6 hours a day in his production; (2) inspecting a product requiring maximum detail perception; (3) inspecting a product whose density is such as to require fluoroscopy close to 140 kv peak; (4) being so dependent on fluoroscopic inspection that a failure would shut down production; and (5) being generally satisfied with the results of conventional industrial fluoroscopic equipment.

Such a customer was located near Milwaukee, Wis., whose chief product required that a thermal heating element approximately 1 inch in diameter and $2^{1}/_{2}$ inches long be inspected. The windings in such an element are so fine that they cannot be distinguished on the conventional fluoroscope running at 110 kv peak and 5 mm. Using fluoroscopy he was able to detect 3/16-inch or larger voids in the ceramic thermal shield and, as such, was pleased with the result. The inspection process required alternating operators working in a darkened room throughout the day. Rejection rates of the elements over the previous 8 months had been averaging 2 per cent.

This fluoroscopic installation was replaced by the image system. The voltage needed for penetration of the object could be lowered to 70 kv peak a drop of 40 kv peak over fluoroscopic practices. The image of the object inspected was increased in size to five times normal at which point the individual windings became clearly distinct under full room light. Voids averaging 1/16 inch in diameter in immediate contact with the wire can be seen easily. This increased detail perception caused the rejection rate to

jump to 25 per cent, forcing a complete redesign of the element by the vendors. This example is typical of the utility of such an inspection device.

OTHER USES OF THE IMAGE SYSTEM

One of the great advantages of such an image system is the fact that the entire image is electronically scanned. This removes the need for any mechanical scanning devices, as would be required in the case of a single-beam inspection system. A second advantage is that by the use of an "absorption negative" of the object being examined, automatic trip circuits detect and reject any object having a defect recognizable by a change in transmission. It is believed, at present, that the majority of inspection systems constructed in the future, utilizing these tubes, will be ones in which the absorption negative removes the need to display the completed image on a monitor tube.

Should a permanent record of the object be desired, two recording methods are available. The first is to simply photograph the monitor screen. The second method is slightly more involved; it utilizes the storage of the image as an electric signal on magnetic tape. Either method is feasible by virtue of the electric output of the system.

SUMMARY OF X-RAY IMAGE INFORMATION

The system described combines the features of many sciences. It is not by any stretch of the imagination the panacea of the X-ray inspection problem. It is merely one more tool available in the art of nondestructive testing. The extent of its use should be governed by many considerations. As an aid in making this decision, it is hoped that the foregoing comparison of X-ray inspection methods will serve as a guide.

FILM

ADVANTAGES	DISADVANTAGES
1. High sensitivity	1. Long single exposures
2. Perfect storage	2. Processing
3. Permanent record	3. Expensive
4. Contrast sensitivity, 2 per cent	4. Delay in viewing image
5. High detail sensitivity	
6. Simple	

DIRECT FLUOROSCOPY

ADVANTAGES	DISADVANTAGES
1. Instant viewing	1. Observer position fixed to object
2. Trouble free	2. Health hazard
3. Simple	3. Operator fatigue
4. Inexpensive	4. Limited sensitivity
5. Long lived	5. Limited detail
	6. Contrast sensitivity, 8 per cent
	7. Usually requires dark adaptation
	8. No permanent record

DIRECT-IMAGE INTENSIFYING TUBE

ADVANTAGES	DISADVANTAGES
1. Instant viewing	1. Limited health hazard
2. High sensitivity	2. Small image size
3. Fine details	3. Observer position fixed to object
4. Contrast sensitivity, 4 per cent	4. Limited dark adaptation of eye
5. Image brightness enhanced	5. 30-kv peak supply needed
6. Permanent record available through combination with photography	

X-RAY SCANNED-IMAGE PICKUP TUBE

ADVANTAGES	DISADVANTAGES
1. Instant viewing	1. Contrast sensitivity, 8 per cent
2. High sensitivity	2. Detail sensitivity, 0.25 mm
3. Remote viewing in bright daylight	3. Electronic circuitry required
4. Permanent record available on tape	4. Basic limitation of detail by scanning process
5. Permanent record available by photography	
6. Unlimited number of viewing stations	
7. Magnification of image without loss of detail	
8. Contrast electronically variable	
9. Image electronically permitting absorption negative technique	
10. Tube operates at 50 volts	

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Radiation-Control Measures

A survey, according to *Forum Memo*, reveals that 28 states are engaged in some kind of state health and safety activity that are concerned with nuclear radiations and materials.

The survey shows: (1) Two states have enacted specific radiation codes; (2) Thirteen states have set permissible limits for radiation exposure and/or have amended existing regulations to include some control of radiation hazards; (3) Seven states have set up commissions, study groups, or co-ordinators, whose responsibilities in part will be concerned with radiation safety; (4) Six states are known to be contemplating setting up radiation codes and are currently applying broad powers of other codes to exercise controls. The remaining 20 states are not known to have given special attention to radiation measures, as yet.

Of the 15 states now exercising some form of radiation control, eight have set permissible tolerance limits for external exposure at 0.3 roentgen per week; two are using 0.1 roentgen per day; one is using 0.05 roentgen per day; and four states have not set permissible tolerance limits.

In Educational Circles

Beyond Engineering

M. D. HOOVEN
PRESIDENT AIEE

In a message to electrical engineering students, President Hooven briefly outlines the technological advances and achievements of the past which have led to today's highly industrialized civilization. The engineer's role and responsibilities are emphasized.

THIS IS AN ENGINEER'S WORLD. Within sight is the possibility of the creation of a physical Utopia—a civilization constructed on a technology which has learned to grow upon itself. Among the most privileged inhabitants of this new civilization is the young electrical engineer on whom must fall the burden of handling an increasingly complex technology. Eagerly sought after by industries of every complexion, the young engineer may, if he so elects, enter research, design, development, operation, production, application, teaching, writing, or almost any variation of activity for the practice of his profession.

Immediately on starting to practice, he has the privilege of taking a positive part in the interchange of ideas by active work in AIEE. He enters an intellectual world open to anyone with ideas.

He is assured of a reasonable competence. He serves an ancient and respected profession; and, like most professionals, his community prestige and, incidentally, his remuneration from that same community increases until old age requires his withdrawal from activity. He is held in respect by his neighbors.

He leads his people into the unknown. He is today's pioneer with a limitless number of frontiers to crack. He has the privilege of being the inheritor of the great American tradition of newness and growth. Electrical development of a decade or so in the future can be foreseen but dimly; whatever it is, it will be extraordinary.

Representing one of the youngest branches of engineering, the electrical engineer is at the hub of modern technology with his command over electrical energy whether used for supply, control, or communication. The use of electrical or electronic devices pervades all portions of the art. It is the electrical engineer's privilege to serve not only the general community, but also other facets of the engineering profession as well.

Privilege has its obligations. It would be trite to say that the engineer's obligation was met when he had done his job well—even superlatively well. Engineers have done their jobs well since the beginning of time,, and the civilizations they served have failed. This splendid new world, now so attractive, has no assurance of permanence. And this civilization is not, of course, *the* civilization that is the sole flowering of the milleniums. In his *Study of History*, Arnold Toynbee finds 21 civilizations which have reached full flower, plus others which, like the Eskimos or the Polynesians, had physical difficulties too great to be overcome by the development of even the most ingenious of engineers. The names of those civilizations which have come to fruition call to mind the pageantry and panoply of the past, the glamour of the days now gone. Take a few: Egyptiac, Andean, Syriac, Arabic, Far Eastern, Hellenic, Indic, Orthodox, Western. All these and others too, except the Western Civilization, are gone. Many of them, like the present one, were civilizations built around a complex technology. Their engineers were the privileged persons of their day. A quick review might indicate whether or not their technical people lived up to their obligations.

The first great engineering project was the pyramid, a structure designed and constructed 5,000 years ago at the very beginning of recorded history. The pyramids still stand as mute evidence of a remarkable engineering civilization—a civilization which brought Egypt out of barbarism, flourished for but a few hundred years, and then declined. At no time in history has the planner and director of works ever occupied a higher position in life than he did in the Egyptian Golden Age. Using as tools only the lever, the inclined plane, and the wedge, he was able, with the help of many superintendents, foremen, accountants, and clerks, to erect structures still numbered among the "Seven Wonders of the World." These ancient engineers, like their modern counterparts, were concerned with the welfare of their labor, the procurement and transportation of material, and the necessity of meeting construction schedules. Apparently, 100,000 men were

Full text of an address presented in conjunction with the Metropolitan Student Night program at the AIEE New York Section Meeting, New York, N. Y., December 8, 1955.
M. D. Hooven is electrical engineer with the Public Service Electric and Gas Company Newark, N. J.

withdrawn from useful production to construct nonproductive monuments.

The Pyramid Age came to a quick close. After a period of technological advance, unparalleled in history until modern times, Egypt stagnated. H. G. Wells says that the unmeaning sepulchral piles of an almost incredible vastness, erected in an age when engineering science had scarcely begun, exhausted the resources of Egypt through three long reigns and left her wasted as if by a war. James Kip Finch, speculating on the same subject, gives several possibilities, such as the maintenance of the status quo by the ruling class and the treatment of the peasants as mere machines; the presence of the Nile and the consequent lack of necessity for roads or irrigation; and the fact that the Egyptian was a pure empiricist who never asked "Why?" In any event, except for a brief flurry of temple building a dozen centuries B.C., Egypt's technological contributions have been as nothing for the last 5,000 years.

While the earlier Mesopotamian civilization had no contributions comparable to the pyramids, many empirical developments occurred in the construction of their palaces, irrigation systems, and temples. But the civilization of the Golden Crescent is gone. Toynbee, in discussing Iraq, asks why its whole irrigation system, which had been successfully maintained for thousands of years, was allowed to go to ruin, and answers that this lapse in technique was, in fact, not the cause but the consequence of a decline due to social causes. In India development of cities was conventional. In China the Great Wall was a huge enterprise, but not startling technically. Greece, however, took the flickering torch of technological progress from stagnant Egypt. The Greek master builder, or arch technician, as he was called, had harbors to build, water supply systems to plan and install, surveying chores to do. The Greek technicians had a remarkable feeling for obtaining the right answer. Certainly the beauties of her temples show an intuition of quantitative engineering design skills. Mathematics and mechanics emerged as an intellectual activity. Greek technology, however, suffered from the attitude that the contemplative life was the only kind to be looked up to, that utilitarian practices were for slaves. Indebted as we are to Greece for our philosophies and theologies, it is quite possible that the development of science and engineering and, thus, of modern civilization was retarded 2,000 years by Greek abhorrence of the practical.

Rome was the direct heir of the remarkable Greek advances in mathematics and mechanics. Roads and aqueducts still testify to the Graeco-Roman master builders' skill. The master builder, how becoming a part of the military because of the need for military roads and fortifications, moved at will over the Western World. The word "ingenium," which according to Webster came from *in plus genere*, to bring forth or produce, was applied to a military contrivance. Battering rams, catapults, ballista, became known as "ingenia," ingenious devices. Eventually the inventor or operator of these engines of war became known as the "ingeniator," the "ingenious one."

Great as were the engineering accomplishments of the Romans, their empire fell. Too much dependence on

Among the AIEE New York Section members who attended the annual Metropolitan Student Night, sponsored by the Power and Industrial Divisions of the Section, December 8, 1955, in the Engineering Societies Building, were, left to right, seated, W. B. Morton, chairman, AIEE Committee on Student Branches; President Hooven; R. T. Weil, Jr., Section chairman; L. J. Hollander, chairman, Section student committee; standing, AIEE Secretary N. S. Hibshman; L. F. Stone; H. W. Marquardt, Division program chairman; J. C. Hoyt, Division chairman; and J. D. Tebo, chairman, AIEE Committee on Technical Operations. Some 200 students from 10 colleges and universities attended the meeting.

empiricism and the tendency to look backward for authority probably prevented the Roman engineer from assuming the leadership that might possibly have saved it.

The intellectual awakening of the Renaissance gave the engineers the first great prophet of the profession, Leonardo da Vinci, whose 500th birthday was celebrated recently. He recorded in his notebooks sketches of engineering devices in their modern sense, ranging from airplanes to diving bells. Since they were not published until centuries later, their potentiality of rapid development was lost. Lost too were the trade secrets of the guilds, regarded by some as the forerunners of the profession, but perhaps more correctly regarded as the forerunners of the mechanics' trade union. Certainly the guilds and master builders of the period had in no way attained the status of a profession in terms of ministry to the people wherein developmental ideas are freely interchanged for the benefit of all. Neither Da Vinci nor the guild had great open forums, such as AIEE, for the presentation of new concepts.

The Great Inca who ruled the Andean community was certainly one of the "ingenious ones." In a barren community with but a few inches of soil clinging to the tops of arid plateaus, he was able to sustain life for hundreds of thousands of humans. The Spaniards took over almost without resistance. The intellectual Incas, a privileged group of individuals, had never bothered to step outside their own sphere. The peasants had no reason to defend them against just another set of bosses.

The Osmanlis, founders of the Ottoman Empire, developed perhaps the best group of industrial engineers known by an opposite tactic. They trained their management forces from children taken in slave raids. No member of their aristocracy could enter the management group except occasionally by competitive examination. But the Ottoman empire went down even though their technology was excellent. Was it because their engineers were engineers only?

The answer seems to be clear. Some 20 civilizations have failed. This world is not such a simple one that one reason for failure can be given for all. But through all these disintegrations runs a common thread. The "ingenious ones" did not look beyond their interesting puzzles. The brightest minds were concerned with development of techniques. Too few of them paid attention to the life which surrounded them.

A queer combination of confidence and uneasiness confronts the scientist and engineer of today: confidence in his ability to control the physical world; uneasiness concerning the end to which he is leading his civilization. It seems to be indicated that the engineers of the past failed to keep alive the culture which they served because they were too well devoted to techniques. The answer to what lies beyond engineering is a simple one. It is the obligation of the engineer to be a dynamic part of his community.

Such a choice is not an easy one. Politics, church, school, scouting, and social service are all time consuming; some, controversial. Adding to a life already full to the brim of the most interesting activity conceivable, community burdens may seem intolerable. But such an obligation must be served.

A second obligation is to engineering as a profession. The wedding of science and engineering a century or so ago and the concurrent rise of the engineering societies shaped the profession as it is today. In common with the other learned professions, engineering considers its practitioners to be individual servants of the public, while at the same time being students of a common discipline. The obligation to maintain independence of mind plus interdependence of association for the exchange of ideas is common to all engineers. The electrical engineer finds his society alert to these duties. AIEE particularly prides itself on its quickness of response to the wishes of its members. Since eternal vigilance is the price of liberty, each individual must continually guard his relations with his client, whether the client be a person, a governmental unit, or a corporation, in order to be certain he maintains his independence of judgment. Fighting for the freedom to be fired may very well be one of the individual engineer's obligations.

Finally, there is the obligation of the engineer to himself. His services to his community will vary directly with his physical health. Of even greater importance is the quality of his work as affected by his own mental well being. The much discussed post-baccalaureate slump—a period of "do-nothingness" brought about by the kind of routine chores which may go with starting a new job—must be avoided at all costs. Since the engineer is part of a varied and deep culture, he must include in his thinking background poetry, philosophy, literature, and the like. He does not have the choice of avoiding them.

Beyond engineering lies the obligation of entering into a full social and intellectual life. You are invited.

Employment Lecture Series for Rutgers University Branch

The program formulated for the AIEE-Institute of Radio Engineers (IRE) Student Branch at Rutgers University, New Brunswick, N. J., for 1955–56 is in the form of a lecture series with subject matter about the various fields of electrical engineering, such as: research, development, sales, production, management, etc. A speaker will present a lecture in each of these fields at each meeting.

To date, the meetings have been about research, development, manufacturing, and sales. As an introduction to the series, Dean E. C. Easton gave a lecture on the basic concepts of the fields to be described and their relation to formal education.

This program is for the purpose of providing a better understanding of the employment of electrical engineers and the qualifications necessary for success in each type of field, and should assist the student to choose a particular field upon graduation.

So far, this program has been well received with about 80 per cent of all electrical engineering students attending each meeting.

"The Difficulties Young Men Have to Contend with . . ."

W. B. MORTON
FELLOW AIEE

The author presents to electrical engineering students a special message discussing the basic purposes of the Institute, as well as the advantages of active participation in the AIEE Student Branches.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS is now engaged in a thorough examination of its organizational structure. The rapid growth in membership and activities during the past decade has produced indications that there is need for planning now for greater service in the future. It is imperative that any progressive organization periodically examine its objectives to insure that they be given expression in terms of present and future needs. In his technology the engineer continually asks, "Why?" Only after the "why" is settled is it time to proceed with "how" to gain the objectives. The basic over-all objectives of the Institute are set forth in the Constitution: "Its object shall be the advancement of the theory and practice of Electrical Engineering and of the allied Arts and Sciences, *and maintenance of a high professional standing among its members.*" (Italics mine.)

One of the most vital areas of service of AIEE is in the field of engineering education. AIEE is deeply concerned with the future members of the electrical engineering profession and devotes much of its resources in money and effort to its Student Branches. It is pertinent to inquire why this should be done. What is the basic reason for engineering students to associate themselves into a Student Branch and become a part of their professional organization? The answer seems to have been stated clearly at the very beginnings of the organized engineering profession as we know it today.

> "It was toward the end of the year 1817 that a few gentlemen, then beginning life, impressed by what they themselves felt were the difficulties young men had to contend with in gaining the knowledge requisite for the diversified practice of engineering, resolved to form themselves into a society."

That is the simple story published years ago in a British journal of the beginning of the organized engineering profession. So began the Institution of Civil Engineers which received a royal charter in London in 1828. ("Civil" at that time meant all engineers other than military.) A few young men recognized "the difficulties young men have to contend with" in becoming engineers in the professional sense. They resolved to organize and did.

The problems that young men trying to become engineers in 1817 had to face were real and tangible. There were practically no schools, very few books, no journals, and no general access to the few practitioners who had gained some knowledge and experience in building roads, bridges, structures, and the few crude engines then known. Existing books were costly and hard to obtain. Few people had the opportunity to apprentice themselves to masters who had knowledge and experience to share. So these young men organized to share their books and start a library; to invite experienced men to meet with them and instruct them; to share their own experiences and systematically collect and record existing knowledge; and to make an organized effort to extend the frontiers of the art and science. The difficulties young electrical engineers had to contend with were just as real and tangible when AIEE was founded in 1884 and again when the AIEE Student Branches were started about 18 years later.

The purpose of all organizations basically is to overcome difficulties and gain objectives—to overcome physical, mental, financial, and social limitations of one individual, or many individuals, working alone. A college is an organization of young men in search of instruction they could not get individually. Even today, when a bright young man can purchase many books and subscribe to magazines and otherwise obtain some of the tools of learning, he must organize with others into a student body to share the benefits of personal instruction, laboratory facilities, and a chance to live and work with his contemporaries.

DIFFICULTIES TODAY

BUT WHAT POSSIBLE DIFFICULTIES do college students have to contend with in gaining the knowledge requisite to the diversified practice of electrical engineering today? Why should they form themselves into a Branch of AIEE? Any young man with an I.Q. of 120, an interest and aptitude for electrical engineering, and a reasonable amount of determination can go to college. There he finds many more books, journals, and magazines than he can possibly read. There are lectures, advisers, and meetings beyond anyone's ability to hear. Finally, there is a waiting line of recruiters anxious to employ the young graduate and start building his professional experience as part of his employment.

Perhaps one of the difficulties young men have to contend with is recognizing that difficulties exist. Another is that of recognizing how all this abundance came about and what is required to keep, develop, and yet not permit it to degenerate into chaos. There is also, of course, one

A special article written by the Chairman of the AIEE Committee on Student Branches.

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limitation that is the same today as it was in 1817 and in 1884: there are only 24 hours a day and 168 hours a week. One big difference is that the engineering student today is facing a highly organized world; one in which unco-ordinated individual effort is seriously handicapped.

FUNCTIONS

THE AIEE STUDENT BRANCH still serves all of its earlier functions of bringing students together to share knowledge and experience and to command the help of practicing experts. But more important is the practice of the skills of co-operative effort themselves: to organize with an objective and define it; to plan and execute in detail; to persuade and lead; to communicate successfully; to take and share responsibility; to evaluate human motives and efforts; and to make group decisions, and share the credit or blame for results.

Today there are 143 AIEE Branches in our schools and colleges, each offering unlimited opportunities for the young man to share his learning, experience, and knowledge with other young men.

The AIEE Student Branch can and should be an important vehicle for education and training of electrical engineers. It is not an extra-curricular activity. It is a co-curricular activity. But its objectives must be correctly defined and understood. Merely to hold meetings and attract crowds is hardly enough. Football is a great collegiate institution, instilling in the student body loyalty, teamwork, sportmanship, and the will to succeed. If the objectives of the game, as played by the colleges, were simply the obvious one of transporting a small bag of wind from one end of a lawn to the other, it would hardly be worthy of all the time and attention devoted to the enterprise. Here, as in so many human activities, the by-products contain the values.

Most of the things men want from life are by-products. They cannot be made or achieved directly. We all want money, power, approbation, and appreciation. We cannot get any of these directly. We cannot make money—that is a Federal offense governed by laws about counterfeiting. We cannot achieve the authority to carry out our ideas or to direct and lead others by merely putting a sign on our desk, "I am the boss." We cannot win the approval and appreciation of our fellow men by sending out a circular to the effect, "I am a fine fellow and you ought to admire me and give me honors, offices, and sundry tokens of your respect." It will not work in the long run, although it is not infrequently tried. All of these things are by-products of service rendered intelligently and without thought as to the results in terms of personal gain.

ADVANTAGES

YOUNG MEN sometimes ask, "Why should I join AIEE? What do I get for my dues?" Past President Robertson gave an excellent answer to this question in an address delivered before the conference of Section Delegates at Los Angeles two years ago. He pointed out that first of all the Institute's income is twice that from dues alone. This income is all spent on services to the members. Hence, there is twice the dues money value available to any member who will take advantage of all the services offered to him; and since a student's dues are only from a third to a fifth of a member's, there is little question as to the direct tangible return on dues invested in AIEE membership.

However, if that is all the prospective member wants, AIEE is not seeking him out as a prospect for membership. AIEE is not a mail order membership operation. AIEE members are invited personally to join. Their technical and personal qualities must be certified by four members. If the prospective member wants to become associated with AIEE, a world-wide fraternity of electrical engineers, and to use AIEE as a channel for his contribution to the profession; if he wants to serve and let the by-products take care of themselves, we do want him as a member. He will profit immeasurably if he joins AIEE with this objective in mind. Others will profit by his contributions.

The AIEE Branch may be likened to a team, where the Counselor is the coach and the Chairman is the captain. But there is no limit as to the number of members on the team—the more the better. Manpower efficiency is not an objective. The purpose is to teach and practice the skills of organization, co-operation, and professionalism, using the common interest in electrical technology as the basis for working together.

The planning of an AIEE Student Branch Meeting can be occasion for a number of students to contribute a service, to co-ordinate their efforts, to plan, and to execute plans. It is an opportunity to communicate broadly with the student body and to practice the arts of communication in the meeting itself. It calls for thoughtfulness and courtesy to the speaker and to the audience. It teaches self-discipline, understanding of human nature, and broadness of view. The student has an opportunity to develop writing and speaking ability and the technique of influencing others. All of these are the common skills of co-ordination and co-operation so much needed in modern industrial and professional life. If he is to succeed, the practicing engineer must possess these skills to as great a degree as his technical skills.

The AIEE Branch affords unlimited opportunity for independent activity and initiative on the part of the students for cultivating those qualities and skills essential to the practicing engineer, but difficult to acquire in the classroom. Development of these qualities is aided by making use of the AIEE publications, by taking part in the work of the Branch, by meetings and entering into discussions with other student engineers, by presenting papers, especially in the Branch competitions, and by observing the techniques of older practicing engineers when they visit the branch to share their knowledge with the Branch members.

Affiliation with AIEE, the largest professional society in the world (58,000 members, including students), immediately adds prestige to the student engineer. It is a start toward having his name listed, along with all of the active and outstanding members of the electrical engineering profession, in the AIEE Membership Directory when he

transfers on graduation to grade of Associate Member. This is a mark of distinction that provides an excellent start in his profession.

AIEE is the only electrical engineering society that is dedicated not only to the advancement of the arts and sciences, but also to the advancement of its members professionally. AIEE devotes a considerable part of its resources and time of its members in activities of a purely unselfish professional nature. These areas include sponsoring and actively participating in the work of Engineers Council for Professional Development, which has accomplished much in raising the standards of education and in helping young men to become better engineers and useful members of society.

Another field of AIEE participation is in Engineers Joint Council, the nearest approach we have to a Unity organization. AIEE is one of the most active societies working consistently toward ultimate complete unification of the engineering profession. AIEE, in conjunction with ASME, ASCE, and AIME maintains the finest engineering library in the world.

We can sum up "mathematically" this discussion with an equation, $AIEE = TC + P^n$. In other words, AIEE adds up to Technical Competence plus Professionalism—Professionalism to the nth power. Technical Competence is a requirement of membership. The value of n is a direct ratio of your participation in the professional work of the Institute. The results are "you" multiplied by the extent of your participation.

The difficulties young men have to contend with today are much more complex than the simple and obvious ones attending the beginning of our organized profession. They are less obvious but they are difficulties which young men can overcome by joining together and working together in the professional society serving their interests. For the electrical engineering student, this is the American Institute of Electrical Engineers, the one society which serves all electrical engineers regardless of specialization.

The Graduate Engineer

His Training and Utilization in Industry

S. B. INGRAM
FELLOW AIEE

With the shortage of engineering talent, the effective utilization of technical skills in industry is essential. The author describes the approach being taken by Bell Telephone Laboratories in solving this important problem.

WITH THE INCREASING COMPLEXITY of our technology and with the very high level of industrial activity prevailing in recent years, engineering talent is in very short supply. It is, therefore, important for us to conserve it carefully and use it efficiently. We must use our engineers so that they are as productive as possible. This is one thing that we mean by full utilization. It means using engineers for a professional grade of work only. But we should look at the problem more broadly and consider another aspect of full utilization. Our technology is complex and is going to continue to increase in complexity. It is strongly believed that our economy is going to continue to function on a high level. The number of potential engineers has a definite limit because only a fraction of our secondary school students are capable of or interested in pursuing the rigorous discipline of sound engineering training. Therefore, we should be concerned not only with the productivity of the engineer today, but also with what his productivity will be in the future. We should be concerned with full utilization over a period of time. This, then, leads into the second aspect of the full utilization of engineers, the continuing development of the engineer after his graduation from college.

This discussion will be limited to one broad area of engineering, research and development, taking the field of communications as an example and the Bell Telephone Laboratories as a specific case.

Essentially full text of a conference paper presented at the Fall General Meeting, Chicago, Ill., October 3–7, 1955 and recommended for publication by the AIEE Committee on Education.

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EFFICIENT USE OF PERSONNEL

IN COMMON with the rest of industry we are attempting to utilize the members of our technical staff, the engineers and scientists, only for work which makes use of the advanced academic training with which they are equipped. The rest of the technical job frequently can be done as well, and sometimes better, by the other members of the technical team, the technician, the draftsman, and the shop mechanic. In our organization are grouped together these categories of technical workers who also work on the technical job but in a supporting capacity as the assistant technical staff. Within the last five years, we have increased the ratio of assistant technical staff to technical staff by 50 per cent until now the numbers in each group are approximately equal. The biggest increase is in the technician category. Where formerly there was one tech-

nician for every four members of the technical staff, there is now about one for every two.

QUALIFICATIONS FOR ADMISSION

WHILE INCREASING THE SUPPORT given to the professional technical staff, the minimum qualifications required for new recruits to it have been continuously increased for many years. Our practices have crystallized with the post World War II recruiting, the introduction of a Communications Development Training Program for college graduates, and the clarification of policy with respect to the use of technical aides. About 20 per cent of the new additions to the technical staff are trained to the Ph.D. level. The training program which is given to all other new college recruits at the bachelor's or master's level we consider at least the equivalent of a year of graduate work. Much of it is fundamental in content although it is not a degree program, and the engineers entering it are carefully selected on the basis of their academic records. I think, therefore, that it is fair to say that the minimum requirement for our technical staff is a master's degree or the equivalent.

THE TECHNICIAN AREA

WITH SUCH STRINGENT REQUIREMENTS for admission to the technical staff, we are trying to make it a group engaged in technical work of a strictly professional character. Thus, a challenging level of work exists in the subprofessional area, leaving room for the more capable employees in the technician grades to grow to the top technical aide classifications without diluting the quality of the technical staff. Three technical aide classifications have been defined. The lowest, technical assistant, requires preparation to the technical institute or equivalent level. Technical assistants work under close direction of more senior members of the organization, in a supporting capacity. The second, technical staff associate, requires greater experience on the job, demonstrated ability to carry on work of a greater degree of complexity and with less supervision than is given the technical assistants, and sometimes more formal training. The third, senior technical associate, is a classification carrying sufficient responsibility and latitude for the exercise of independent judgment to make it qualify for exemption under the Fair Labor Standards Act. In general, it requires a formal preparation equivalent to a four-year college course. It involves the ability to undertake work independently on a project basis. In many organizations this work would be classed as work of an engineering grade. Salary ranges of all three classifications are commensurate with the responsibility involved. Progress from one classification to another is controlled by a committee which assesses documentary evidence of an employee's demonstrated ability to qualify for the next higher classification. A few outstanding technical aides are able to receive full professional status as members of the technical staff by demonstrating on-the-job ability to make technical contributions of fully professional grade. Technical aides who receive accredited evening engineering degrees with sufficient distinction to meet the high recruiting standards for the technical staff may then be reclassified and enter the training program as would a new recruit from college.

COMMUNICATIONS DEVELOPMENT TRAINING PROGRAM

THE NEW COLLEGE RECRUITS at either the bachelor's or master's level enter the Communications Development Training Program, which occupies their entire time for their first year with the company and part of their time for the following two years. In this program our objectives primarily are long range. We are concerned, of course, with orienting the new recruits in the organization and informing them of the many aspects of our special technology so that they may become effective contributors to our current development programs early in their careers. But although these aims are important, we could not justify a training program of such an extensive nature for such limited objectives. We are keenly aware that these young graduates are the new blood of our technical organization. As such, it is their ultimate potentialities for development rather than their immediate productivity which really counts most. We are concerned with providing these new technical staff members with engineering training of a fundamental nature which will equip them to attack the complex problems of the future by the most effective analytical methods available. We know that in the dynamic technology of the mid-20th Century no training today can equip an engineer to solve the problems of tomorrow. If he is to function most effectively, his education and development will have to be a continuing process and he himself will have to be responsible for keeping his technical capabilities abreast of the technical arts of the future. Experience has shown that whole new technologies evolve from time to time and that our engineers need to master new areas of knowledge and new skills foreign to their previous experience. We are concerned, therefore, with laying an educational foundation on which a sound structure of continuing technical self-development can be built. We believe that the best foundation for such continuing self-development consists of an education in depth and the attainment of technical maturity and not the mastery of numerous specific skills. All of these considerations have led us to the development of a curriculum much more fundamental in content than one might, at first glance, expect to find in an industrial training program.

History of the Program. This approach to the problem was learned by experience. The C.D.T. Program, as we call it briefly, was initiated in 1948. In the original curriculum the primary emphasis was on courses in the various areas of our technology; for example, radio transmission, wire transmission, outside plant, and courses in automatic dial switching. Experience showed that these courses, taught by members of our own technical staff, specialists in their fields, had a tendency to become handbook and vocational types of courses, informational and specialized rather than fundamental. The students suffered from mental indigestion as a result of the mass of detail with which they were presented. In 1952, an evaluation of the program was made and the conclusion was reached that our objectives would best be met by offering a curriculum much

more fundamental in nature than formerly and similar in many respects to the graduate programs offered by the universities. It would differ from the university graduate programs in that it would be oriented toward communications technology in a broad sense and would draw heavily on the extensive resources available to us in our own research and fundamental development areas, as well as on the published literature for new knowledge, concepts, and theory. Also, it would include courses aimed specifically toward the objectives of orientation in the company and indoctrination in our own technology. A series of rotational work assignments in technical departments, following the pattern established in the original program and also aimed at orientation, would be continued.

This is the program as it exists today. For the first year, the entire time of the new man is devoted to the program. Classroom work consists of lectures and opportunities for recitation on three days of each week. Time is provided for study during regular working hours, but many students in the program spend from 10 to 15 hours per week in outside preparation. The remaining two days are spent on rotational assignments in the technical departments. In the second and third years, classroom work is reduced to one day per week, and the student having completed his rotational assignments enters the technical department for which he was hired initially, which is called his sponsoring department, and he is integrated into one of its regular projects.

The C.D.T. Courses. The first-year courses are fundamental in nature, and all students pursue the same courses of study, as listed in Table I.

Table I. Communications Development Training Program

First Year Curriculum

	First Term	Second Term	Third Term
Mathematics	Analysis I	Analysis II	Fundamental Circuit Theory
Physics	Physics of Waves	Atomic Physics	Solid State Physics
Communications	Probability and Statistics	Logic and Switching	Communication Theory
Orientation	Bell System I	Bell System II	Bell System III

In those instances where a student has considerable advanced training, credit is sometimes granted for courses in which he already is well prepared. Such a student takes a reduced program or, with others like himself, studies advanced topics outside of the regular curriculum.

In addition to the orientation course described, there are three groups of courses dealing with the fundamental disciplines of mathematics, physics, and communications. The mathematics group deals with topics of particular importance in the communications field, functions of a complex variable, the LaPlace transformation, Fourier analysis, linear vector spaces, and the analytic aspects of linear circuit theory. The physics group contains a course in the physics of waves, inasmuch as wave motion is the basis of all communications phenomena; atomic physics, which is often not included in undergraduate engineering curricula; and the physics of solids, a subject of great importance now that the transistor and related semiconductor devices promise to revolutionize the entire technology of communications during the engineering careers of these young men. The communications group starts with a course in probability and statistics, in which the emphasis is placed on the interpretation and significance of laboratory data. It is followed by courses on logic and switching, largely the mathematics of digital systems; and communication theory, including the concepts of information theory.

The orientation course, called the Bell System, runs throughout the year. It devotes approximately one third of the time to orienting the student in the training program and in the Bell Laboratories, introducing him to the interrelations of the various parts of the Bell System, and giving an introductory treatment of engineering economy and of public utility economics and rate making. The remaining two thirds is devoted to a study of the various transmission and switching systems and of the outside plant which constitute the existing facilities of the company.

The second- and third-year curriculum is more specialized and is largely elective. The program of courses which a student takes is determined by his sponsoring department and depends upon the needs of the department as well as on the interests and aptitudes of the individual concerned.

Table II. Communications Development Training Program

Second and Third Year Curriculum

Group A. Required Advanced Courses

Number	Title
A2	Fundamentals of Technical Writing
A3	Semiconductor Devices
A4	Electron Tubes
A5	Electronic Circuits

Table III. Communications Development Training Program

Second and Third Year Curriculum

Group B. Engineering Fundamentals Courses

Number	Title
B1-I	Microwaves
B1-II	Microwaves
B2	Passive Networks and Components
B3	Modulation Theory
B4	Unifunctional Switching Circuit Design
B5	Acoustics
B6	Probability Applied to Traffic Engineering
B7	Design of Experiments
B8	Communications Engineering Materials
B10	Human Engineering
B11	Design for Production and Service
B12	Advanced Mechanics and Dynamics

Table IV. Communications Development Training Program

Second and Third Year Curriculum

Group C. Courses for Specific Areas of Work

Number	Title
C1	Transmission Systems Design
C2	Servomechanisms
C3	Multifunctional Switching Circuits and Systems
C4	Systems Engineering
C5	Radar
C6	Computers
C7	Principles of Mechanism Design
C8	Design Principles of Electroacoustic Apparatus
C9	Design of Relays and Electromagnets

There are three groups of courses, *A*, *B*, and *C*, shown in Tables II, III, and IV, respectively.

Group *A* consists of three courses in electronic devices and circuits and a course in technical writing. These are required of all students, because electronics is basic to modern communications, and experience has shown that almost all engineering graduates can profit by further training in writing and that many need it badly.

Group *B*, a series of 12 courses on what we consider to constitute the engineering fundamentals of modern communications, leads up to group *C*, which deals in a rather specific way with various fields of Laboratories work in both the telephone and military areas. In the interests of brevity, a detailed description of these courses will be omitted here.* Even in the group *C* courses the attempt is to deal with the principles and the methodology of design and engineering rather than to catalogue the information of the various fields. By the time the student reaches this part of the program he has not only the background of the earlier courses, but also from two to three years of company experience so that he is prepared to approach the subject matter in a mature way.

Administration of the Program. The responsibility for the planning and presentation of the courses is vested in appropriate technical departments of the Laboratories in order to keep the curriculum abreast of the most recent advances in the various fields. The research departments contribute heavily to the fundamental disciplines of the first year. The development departments assume responsibility for courses of a more specific engineering nature. In recent years, arrangements have been made with neighboring graduate schools to have certain of the more fundamental courses presented by members of their faculties. This has been done as a part of our program, on our premises, and close co-ordination with our technical departments has been carefully maintained. We feel that this cooperation between industry and education has added strength to our program, and hope that it has been of benefit also to the institutions and to their faculties. We are desirous of extending it in the future.

Little has been said so far about the rotational work assignments which take place during the first year, although they are a most important part of the program. They are designed to broaden the new member and to increase his potential usefulness to the organization. There are assignments to three departments which have been chosen because they offer technical experience of widely diverse types and because of the relation of their work to that of the sponsoring department. In each of these temporary assignments a new member works at a regular and productive job which is a part of the department's regular program. This is in no sense "made work," although prime concern is that the new member learn, rather than that he produce. Care is maintained to see that the grade of work given to the trainee is of professional level. It is intended that in this part of the training program the student encounter in practice the many interrelations of his department with others, and that he learn something of the philosophy of the departments with which he will co-operate in his future work. Moreover, the opportunity to work closely with men in these related departments is of great advantage to a new member. In this way, he becomes acquainted with them, and when he needs advice or assistance in the future, he will know where to go for it.

*An announcement of courses giving specific course outlines is available on request from the author.

OTHER EDUCATIONAL PROGRAMS

WE HAVE SAID that the education and self-development, of the engineer must be a continuing process. Aids organized and informal, are maintained by the company to encourage the members of the technical staff to continue their education after the conclusion of the three years spent in the C.D.T. Program. There is a program of out-of-hours courses taught, for the most part, by members of the technical staff on a variety of technical subjects. These are offered at all major locations and vary in subject matter from year to year according to the interests indicated by the departments through committees organized for the purpose of determining the current needs. They are not limited to the professional level, many being offered for the subprofessional levels of employees. On the other hand, many of them are comparable in level and content to the C.D.T. courses. There is a series of out-of-hours lectures open to all employees on technical topics of timely interest in company technology. New developments, new systems, and new techniques are described by those having firsthand knowledge of them. There is a part-time graduate study plan under which qualified employees can pursue graduate study at neighboring educational institutions toward advanced degrees, taking time off during regular working hours up to a maximum of $7\frac{1}{2}$ hours per week without loss of salary.

In addition to these organized educational activities, the company encourages participation in the affairs of professional societies, has a liberal policy on publication, and supports a technical library of 58,000 volumes and 800 current periodicals.

CONCLUSION

IT SHOULD BE EMPHASIZED that although one approach to the problem of the full utilization of the graduate engineer has been described, an approach that we think is well suited to our particular circumstances in the Bell Laboratories, it is not necessarily applicable to all of industry. The requirements of the research and development area of engineering are somewhat different from those of other areas—for example, of manufacturing, operating, and sales. Among research and development laboratories we are somewhat unusual in our size, in the stability of our staff, in the nature of our industry, and in the long-range character of our technical programs. What is right for Bell Laboratories may not be appropriate in other companies. However, it may be stated, in general, that in thinking of the full utilization of the engineer we should think always of tomorrow as well as of today. The lifetime career of a graduate engineer represents a very long period in the rapidly changing technology in which he is going to play a part.

An Analysis of the Linear Pulsed Oscillator

MARK BIEDEBACH
STUDENT MEMBER AIEE

This oscillator, similar in design to the type used with high-frequency circuits whenever a stable train of pulsed oscillations is required, was constructed especially for analyzing the effect of feedback on the oscillator's transient response. The relation of zeros and poles of a network may be observed experimentally.

IN ACCORDANCE with the expanding program of the servomechanisms laboratory at the University of Southern California, Los Angeles, Calif., it was decided that a linear pulsed oscillator should be constructed for the purpose of giving students an opportunity to study and analyze the effect of feedback upon the roots of the oscillator's transient response.

A pulsed oscillator is a resonant circuit employing feedback. The oscillations are stopped and started at a periodic rate, allowing continuous observation of the phenomenon of oscillator build-up. The unit is a valuable tool, allowing the student an exceptional opportunity to observe experimentally the role played by poles and zeros in the performance.

Since construction was completed in November 1954 (Fig. 1), the unit has been used by over 20 groups of students who have analyzed the oscillator, by plotting its damping factor, damped angular frequency, feedback ratio, and root locus plot. This general type of circuit is used in connection with radar-ranging circuits and laboratory setups, whenever it is desired to obtain a marginally stable train of pulsed oscillations. These oscillations may, in turn, be used to determine the transient response of another network.[1]

The original analysis that follows has been verified by analytical and experimental work.

CIRCUIT DESCRIPTION

REFERRING to the complete schematic diagram, Fig. 2, sinusoidal line voltage is first rectified and then coupled through a cathode follower, where the waveform is clipped because of the plate-current cutoff, to a conventional triode amplifier. The resulting square wave is again rectified by a small germanium diode and applied to the grid of the next triode stage. This triode is made to alternately have zero bias and then be driven beyond plate-current cutoff by the action of the square wave. In the cathode circuit of the tube is an inductance–capacitor combination forming a parallel-resonant circuit. Feedback is then accomplished by applying the entire voltage across the coil to the input of a cathode follower that has a gain slightly less than unity. The output of the cathode follower is fed back in series with a variable resistance to the center tap of the coil. The coil was wound upon a toroidal core resulting in a Q in excess of 100 in the operating region of 12 kc. Also, since the core material is powdered molybdenum permalloy, it has a very high-saturation flux density and a value of reluctance that is quite constant. This produces an inductance characteristic that is constant with respect to the range of a-c and d-c currents flowing through it.

At the point on the rectangular pulse A in Fig. 3A, the grid voltage of the triode has been zero and direct current has been flowing through the tube and inductor. However, at $t=A$, the tube immediately goes to cutoff and current ceases flowing through the tube. With feedback omitted, imagine that direct current has been flowing through an oscillatory circuit which is connected to a switch that is instantaneously opened at the time, $t=A$ (Fig. 3B). Thus, the initial condition exists which causes the circuit to oscillate or "ring." The resistance of the coil and leads causes the oscillations to dampen exponentially when no feedback is present.

At time B, the grid bias immediately returns from a plate-current-cutoff value to zero. The tube itself, then produces a large amount of degenerative feedback (Fig. 3C). From the incremental equivalent circuit the behavior after time B can be visualized. This is equivalent to closing a switch in series with a relatively low value of resistance, thus shunting the resonant circuit and causing the oscillations to damp out in an interval of less than a cycle.

ANALYSIS OF THE EQUIVALENT CIRCUIT

DURING THE INTERVAL from A to B, consider the equivalent circuit of the oscillator, as shown in Fig. 4. The entire voltage across the resonant circuit is applied to the input

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Text of the paper awarded first prize in Institute Prize for Best Student Paper contest, and first presented at the District 8 prize paper competition, May 22, 1955.

Mark Biedebach is a student at the University of Southern California, Los Angeles, Calif.

Fig. 1. Linear pulsed oscillator; top and bottom views

of a cathode follower having an unloaded gain of A and an output impedance here considered to be resistive and of magnitude R_t. If the voltage across the entire coil and condenser is labeled E_1, then the equivalent Thevenin generator produces a voltage AE_1. AE_1 is divided across the internal resistance of the cathode follower R_t, a variable feedback resistor R_f, and one half of the coil. A current I_1 flows in this loop through half of the coil, thus completing the feedback path.

Assigning an inductance value of $L/4$ to each half of the center-tapped toroid, the mutual inductance between the two coil sections becomes $L/4$, inasmuch as the coupling coefficient for two coils on a toroid is very close to unity

$$M = K\sqrt{L_1 L_2} = (1)\sqrt{\frac{L}{4}\cdot\frac{L}{4}} = \frac{L}{4}$$

The magnitude of the total inductance can now be expressed quite simply as L.

$$L_{TOT} = L_1 + L_2 + 2M = \frac{L}{4} + \frac{L}{4} + \frac{L}{2} = L$$

In order to observe the principles underlying the operation of this circuit, one must derive an equation that expresses the nature of the voltage E_1 as a function of time.

Writing loop equations for the two loops through which currents I_1 and I_2 flow, and including the effect of the initial current ρ, one obtains two simultaneous equations for the solution of either I_1 or I_2. For ease of handling, the equations have been written with the aid of Laplace transforms.

$$\left[\frac{L}{4}s + \left(R_f + R_t + \frac{R}{2}\right)\right]I_1(s) - \left[\frac{L}{2}s + \frac{R}{2}\right]I_2(s) = AE_1(s) + \frac{L}{2}\rho \qquad (1)$$

$$-\left[\frac{L}{2}s + \frac{R}{2}\right]I_1(s) + \left[Ls + R + \frac{1}{Cs}\right]I_2(s) = -L\rho - \frac{e_1(0+)}{s} \qquad (2)$$

Note that

$$\mathcal{L}\left[-\frac{L}{2}\frac{di_2(t)}{dt}\right] = -\frac{L}{2}[sI_2(s) - i_2(0+)] = -\frac{L}{2}[sI_2(s) + \rho]$$

and

$$\mathcal{L}\left[\frac{1}{C}\int i_2(t)dt\right] = \frac{1}{C}\left[\frac{I_2(s)}{s} + \frac{i_2^{-1}(0+)}{s}\right] = \frac{I_2(s)}{Cs} + \frac{e_1(0+)}{s}$$

since

$$Cs_1(0+) = q_1(0+) = i_2^{-1}(0+) = \int i_2(t)dt \text{ evaluated at } t = (0+)$$

Where ρ is defined as the initial current in the inductor at the time, $t = (0+)$, and is flowing in a direction opposite to that of I_2, and $e_1(t)$ is the capacitor voltage.

Substituting $I_2(s)/sC$ for $E_1(s)$ in equation 1, rearranging, and multiplying by 2, then

$$2\left[\frac{L}{4}s + \left(R_f + R_t + \frac{R}{2}\right)\right]I_1(s) - 2\left[\frac{L}{2}s + \frac{R}{2} + \frac{A}{Cs}\right]I_2(s) = L\rho$$

This can be combined with equation 2; using these two equations, $I_2(s)$ can be expressed as the quotient of two determinants

$$I_2(s) = \frac{\begin{vmatrix} \left[\frac{L}{2}s + 2(R_f + R_t) + R\right] & \cdot & L\rho \\ -\left[\frac{L}{2}s + \frac{R}{2}\right] & & -\left[L\rho + \frac{e_1(0+)}{s}\right] \end{vmatrix}}{\begin{vmatrix} \left[\frac{L}{2}s + 2(R_f + R_t) + R\right] & -\left[Ls + R + \frac{2A}{Cs}\right] \\ -\left[\frac{L}{2}s + \frac{R}{2}\right] & +\left[Ls + R + \frac{1}{Cs}\right] \end{vmatrix}}$$

The determinant in the denominator is called the system determinant and determines the stability of the circuit. Since the current I_2 flows only through the capacitor, it is directly proportional to the time derivative of the voltage across the capacitor E_1 in the equation

$$sCE_1(s) = I_2(s) = \frac{-L\rho\left[2(R_f + R_t) + \frac{R}{2}\right] - \frac{e_1(0+)}{s}\left[\frac{L}{2}s + 2(R_f + R_t) + R\right]}{L\left(2R_f + 2R_t + \frac{R}{2}\right)s + \frac{L}{C}\left(\frac{1}{2} - A\right) + R\left(2R_f + 2R_t + \frac{R}{2}\right) + \frac{1}{Cs}(2R_f + 2R_t + R - RA)} \qquad (3)$$

This expression is obtained by expanding the determinants and collecting terms.

A quantity β is defined as

$$\beta = \frac{R/2}{2(R_f + R_t) + R/2}$$

or

$$\frac{R}{4(R_f + R_t) + R} \qquad (4)$$

The quantity β is quite similar in its effect to what is termed the feedback ratio in a feedback amplifier, although strictly it does not represent the ratio of voltage fed back to the output voltage as does the feedback ratio in the feedback amplifier. Then

$$2(R_f + R_t) + \frac{R}{2} = \frac{R}{2\beta} \qquad (5)$$

and

$$2(R_f + R_t) = \frac{R}{2}(1/\beta - 1) \qquad (6)$$

Therefore, by substituting equations 5 and 6 into equation 3, one obtains

$$sCE_1(s) = \frac{-L\rho\left(\frac{R}{2\beta}\right) - \frac{e_1(0+)}{s}\left[\frac{L}{2}s + \frac{R}{2}\left(1+\frac{1}{\beta}\right)\right]}{s\left[\frac{LR}{2\beta} + \frac{L}{C}\left(\frac{1}{2}-A\right)\right] + \frac{R^2}{2\beta} + \frac{R}{C}\left[\frac{1}{2}\left(\frac{1}{\beta}-1\right)+1-A\right]}$$

Dividing by $LR/2\beta$ yields

$$sCE_1(s) = \frac{-\rho\frac{\beta}{R}e_1(0+) - \frac{e_1(0+)[1+\beta]}{Ls}}{s + \frac{(1-2A)\beta}{RC} + \frac{R}{L} + \frac{1}{LCs}(1+\beta-2A\beta)} \qquad (7)$$

$\beta e_1(0+)/R$ can usually be neglected as it is very small compared with ρ. See Appendix *A* for further explanation in terms of parameters used.

If β is multiplied by $(1-2A)$, a dimensionless quantity γ is defined. γ is quite similar in its effect to the feedback factor or the open-loop transmission for a feedback amplifier: $\gamma = (1-2A)\beta$. Since A (cathode-follower gain) is always positive and slightly less than unity, γ will always be a negative real number.

Substituting the expression for γ into equation 7, the voltage across the resonant circuit can be expressed:

$$E_1(s) = \frac{-\frac{1}{C}\left[\rho + \frac{1+\beta}{Ls}e_1(0+)\right]}{s^2 + \left(\frac{\gamma}{RC} + \frac{R}{L}\right)s + \frac{1}{LC}(1+\gamma)} \qquad (8)$$

The denominator of the expression is a second degree polynomial in (s), which indicates that the response is governed by a second-order linear differential equation with constant coefficients.

The second term of the denominator plays a particularly important role in the damping of the oscillation. Dimensionally, the terms are reciprocal time constants. The R/L term is a function of the Q of the coil, and contributes to exponential decay even if feedback were absent. The γ/RC term indicates the influence of feedback on the damping by combining γ with the RC time constant, in direct addition to the regular (R/L) term.

INTERPRETATION OF EQUATION

Consider the analysis of equation 8 by first factoring the denominator of the expression for the voltage across coil and capacitor. By completion of the square, one obtains

$$s^2 + \left(\frac{\gamma}{RC} + \frac{R}{L}\right)s + \frac{1}{4}\left(\frac{\gamma}{RC} + \frac{R}{L}\right)^2 - \frac{1}{4}\left(\frac{\gamma}{RC} + \frac{R}{L}\right)^2 + \frac{1+\gamma}{LC}$$

Collecting terms

$$\left[s + \frac{\frac{\gamma}{RC} + \frac{R}{L}}{2}\right]^2 + \frac{1}{LC} - \frac{1}{4}\left(\frac{\gamma}{RC} - \frac{R}{L}\right)^2 \qquad (9)$$

Let a refer to the negative of the constant within the first squared term, and ω_d^2 be equal to the remaining constants (see Appendix *C*). The value a determines the damping; and ω_d is the angular frequency of the damped oscillations.

$$a = -\frac{1}{2}\left(\frac{\gamma}{RC} + \frac{R}{L}\right); \quad \omega_d^2 = \frac{1}{LC} - \frac{1}{4}\left(\frac{\gamma}{RC} - \frac{R}{L}\right)^2 \qquad (10)$$

Therefore, substituting equation 10 into equation 9

$$E_1(s) = \frac{-\frac{1}{C}\left[\rho + \frac{1+\beta}{Ls}e_1(0+)\right]}{(s-a)^2 + \omega_d^2} \qquad (11)$$

Since equation 11 is of the form $k_1 + k_2 s/(s-a)^2 + \omega_d^2$, then, by taking the inverse transform, one obtains the form of the corresponding time solution

$$e_1(t) = K_1 u(t) + K_2 \varepsilon^{at} \sin(\omega_d t + \phi) \qquad (12)$$

This is what one would expect since the coil and capacitor contribute a sinusoidal response that would be combined with exponential damping as a result of resistance in the circuit. But since feedback is employed in the circuit, the resistance that would normally result in exponential decay (Figs. 5 and 6) can be exactly offset by the proper amount of feedback. A greater amount of feedback causes the circuit to be unstable and the response "builds up"

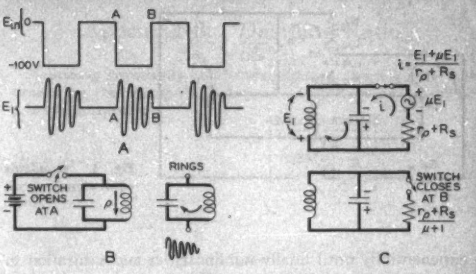


Fig. 3. A—Pulse; B—Oscillatory circuit; C—Degenerative feedback

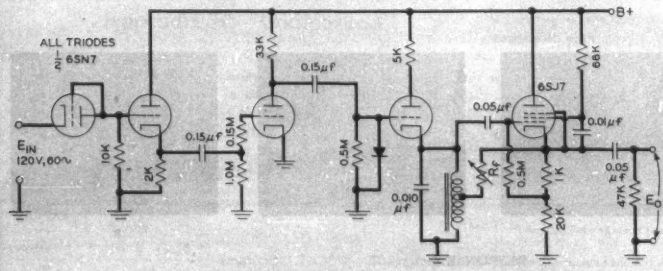


Fig. 2. Linear pulsed oscillator

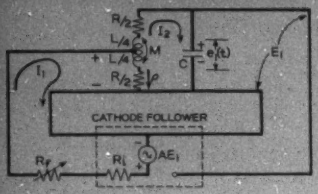


Fig. 4. Oscillator equivalent circuit

exponentially until finally nonlinearities and saturation in various components limit the build-up.

In a linear passive network the transient solution must involve an exponential term with a negative exponent. But in this case, the exponent a can be either positive or negative because of the nature of the active source. Since $\gamma=\beta(1-2A)$, γ will certainly take on negative values whenever the cathode follower gain A is greater than one half.

The gain for the cathode follower is about 0.9. Thus, whenever γ/RC has a negative value that is numerically greater than R/L, the exponent a will be positive, and unstable exponential build-up will occur (Fig. 7).

When $\gamma/RC=R/L$, the system is marginally stable and there will be no damping at all (Fig. 8). This would be the case for a resistanceless coil-and-condenser combination excited by a short pulse or an initial condition. By freezing a coil-and-condenser combination to within a fraction of a degree of absolute zero the circuit can be made to oscillate for weeks.

LOCATION OF ZEROS AND POLES

To AID IN UNDERSTANDING damped oscillations, consider the location of the zeros and poles of this network and their relation to the "complex frequency plane."[2] First of all, rewrite equation 11, modifying it to take the form

$$E_1(s)=\frac{K_1+\frac{K_2}{s}}{(s-a-j\omega_d)(s-a+j\omega_d)} \qquad (13)$$

This can also be written as

$$E_1(s)=\frac{K_1+\frac{K_2}{s}}{(s-r_a)(s-r_b)}$$

where

$r_a=a+j\omega_d$

$r_b=a-j\omega_d$

To explore the roots of the denominator, one can observe them plotted on a complex frequency plane. They are complex conjugate quantities and each can be considered as an exponent of e in a general transient solution.

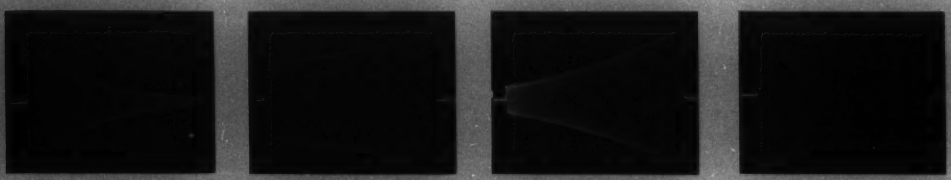
If s were equal to either of the roots in equation 13, either factor of its denominator would become zero. Therefore, these roots are termed "zeros" of the function in the denominator. But, when s takes on values of any of these roots, not only does the denominator become zero, but the entire impedance function becomes infinite. For this reason, the roots may also be termed "poles" of the entire function.

The poles may now be plotted on the complex plane, as shown in Fig. 9. The quantity a which determines damping, also determines whether the poles lie in the right half plane or in the left half plane according as they are negative or positive. If the poles lie in the left half plane, the damping is in the form of exponential decay (Figs. 5 and 6). If the poles are in the right half plane an exponential "build-up" results (Fig. 7). Marginal stability exists when the poles are on the imaginary or "real frequency axis" (Fig. 8).

CIRCUIT APPLICATIONS

THUS, MERELY BY SUBJECTING A NETWORK to a periodic initial condition, one can photograph the transient response immediately on the oscilloscope. If the network has only two poles, one can determine the damped angular frequency by noting the pulse repetition rate and counting cycles. Similarly, the real part on the root is directly proportional to the ratio of the damped angular frequency ω_d and the number of cycles to half amplitude (Appendix B, last equation). The roots can now be plotted on the complex plane. From this plot the impedance and phase shift of the system can be determined graphically as functions of frequency.[3] This would be of considerable value in cases where impedance is difficult to determine accurately by conventional means.

More often, however, the impedance and phase shift or attenuation and phase shift are plotted as functions of frequency from experimental data. The position of the poles and zeros are then determined and the transient re-



5 6 7 8

RESPONSE:

Fig. 5. No feedback. Fig. 6. Stable system. Fig. 7. Unstable system. Fig. 8. Marginally stable system.

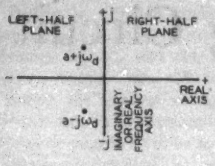


Fig. 9. Poles plotted on complex plane

sponse can be predicted, even with a reasonably complex system.[2]

Aside from the fact that the circuit is extremely useful in illustrating some important principles, what practical purpose does it serve?

Actually, a tuned circuit may be inserted into the oscillator and the response recorded; or the oscillator may be used to generate a sinusoidal signal of varying amplitude and fed to a tuned coupling network or a stage of tuned amplifications. In the latter application, the oscillator may be adjusted for marginally stable operation and a sinusoidal carrier is effectively modulated with a square wave of rather rapid rise time. Thus, the rise time and decay time of the coupling network may readily be determined.[1]

This is of importance in intermediate frequency amplifiers, where one would like to determine the response of the network to the audio portion of the modulated signal. Also, in pulse transmission and television systems the rise time and transient response of pulse transformers and video amplifiers is of major importance.

CONCLUSION

FROM THE ANALYSIS of the pulsed oscillator, it is clear that in designing any type of sinusoidal oscillator, the poles of the system function must be located in the right half plane for oscillation to occur. But the poles should also lie quite close to the real frequency axis in order that relaxation and clipping effects do not take place.

The relation of the zeros and poles of a network to the equations governing its operation has been observed. But even of greater importance, the performance of the oscillator circuit has been predicted, and experimental verification has been given.

Underlying all of electronics is a wonderful pattern of mathematical concepts. The romance of electronics owes much to men who have dedicated their lives to the investigation of its principles.

Appendix A. Comparison

To show that $\beta e_1(0+)/R$ will usually be negligible in comparison with ρ. Using values encountered in actual unit, then $R=13.0$ ohms; $\rho\cong 19$ milliamperes; and $R_{DC}\cong 4$ ohms. Therefore $e_1(0+)=\rho R_{DC}\cong 76\times10^{-3}$ volts. Now $(R_f+R_i)>10k$. Therefore

$$\beta=\frac{R}{4(R_f+R_i)+R}<\frac{13}{4(10k)}\cong 3\times10^{-4}$$

Therefore

$$\frac{\beta e_1(0+)}{R}<\frac{3\times10^{-4}(76\times10^{-3})}{13}\text{ amperes}\cong 1.7\times10^{-4}\text{ milliamperes}$$

which is negligible in comparison with $\rho\cong 9$ milliamperes.

Appendix B. Damping Ratio

A quantity customarily called the closed-loop damping ratio[2] and denoted by ζ as well as the undamped natural frequency ω_n, can be found from equation 8

$$2\zeta\omega_n=\frac{\gamma}{RC}+\frac{R}{L}$$

and

$$\omega_n^2=\frac{1}{LC}(1+\gamma)$$

Therefore

$$\omega_n=\sqrt{\frac{1+\gamma}{LC}} \tag{14}$$

and

$$\zeta=\frac{\frac{1}{2}\left(\frac{\gamma}{RC}+\frac{R}{L}\right)\sqrt{LC}}{\sqrt{1+\gamma}}=\frac{\gamma\sqrt{\frac{L}{R^2C}}+\sqrt{\frac{R^2C}{L}}}{2\sqrt{1+\gamma}} \tag{15}$$

If there were no feedback, β and hence γ would be zero; then (ζ with feedback disconnected)

$$\zeta_0=\sqrt{\frac{R^2C}{L}}$$

Then, in general

$$\zeta=\frac{\frac{\gamma}{2\zeta_0}+\zeta_0}{\sqrt{1+\gamma}}$$

The per unit critical damping ζ is easy to determine from a photograph of the wave train at any condition of positive damping (exponential decay), from

$$\zeta=\frac{0.1108}{2\pi N}$$

Where N is the number of cycles to half amplitude.

Appendix C. Effect of Feedback and Damping Ratio Upon the Damped and Undamped Angular Frequencies

ω_d^2 can also be expressed as

$$\omega_d^2=\frac{1}{LC}\left[1-\frac{1}{4}\left(\frac{\gamma}{2\zeta_0}-2\zeta_0\right)^2\right]$$

where ω_d is the damped angular frequency. Compare the latter expression with

$$\omega_n^2=\frac{1}{LC}(1+\gamma)$$

which is the undamped natural frequency. Thus, the effect of γ and ζ_0 upon ω_d and ω_n can be noted.

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The Linear Pulse Stretching Circuit

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Accurate determination of the width of short-duration pulses, using common low-bandwidth equipment, is accomplished by the linear pulse stretching circuit. An unknown input pulse may be elongated by a known factor, and the wider pulse is more easily measured. Also included is an analysis of the associated waveshaper, two methods of readout using available equipment, and the results of measurements.

PULSE CIRCUITRY in recent years has played a prominent role in the development of electronic equipment. One of the inherent problems in the utilization of pulses is that of pulse-width determination. Since many pulse circuits operate with short pulses, relatively high bandwidth is required.

At present, oscilloscopes are usually employed in pulse-width measurements. However, when the duration of the pulse to be measured is small, considered in terms of the upper frequency limit of the equipment, a large error is introduced. This error may be as great as 100 per cent. From this, it is easily seen that a more accurate method of determining the width of short-duration pulses is desirable.

Since oscilloscopes and frequency counters are common instruments, they can be employed advantageously in making pulse measurements. The linear pulse stretching circuit provides a simple and effective method of both increasing the accuracy of such measurements, while utilizing only common measuring devices. In effect, the pulse stretcher produces a pulse, the duration of which is much longer than and proportional to the unknown width of the input pulse. The stretched pulse, being of longer duration than the input pulse, can be measured more accurately with the instruments available. Solving a problem by more readily determining a quantity proportional to the unknown, rather than the unknown itself, is not a new method. This technique is used frequently in electrical engineering and physics.

Although it is possible to design similar circuits over a variety of ranges of pulse-width inputs, this article will deal only with the one that operates in the range of pulse-width inputs of 1/10 to 5 microseconds. Other specifications of the unit are accuracy and adaptability to the available equipment.

The material of this article is divided into two major sections. The first deals with a theoretical analysis of the unit, and the second with a compilation of the experimental results and a discussion of their significance.

ANALYSIS

THE LINEAR PULSE STRETCHING CIRCUIT basically consists of 3 stages, as shown in Fig. 1. The input pulse enters a clipper which maintains a constant amplitude for all values of pulse amplitude and width in the range of operation. The clipped input signal, the duration of which is unknown, is elongated by the pulse stretcher through conversion from a rectangular to a triangular waveform. The output of the stretcher is converted, in turn, to a rectangular waveform by means of the waveshaper, which consists of a series of amplifiers and clippers. The elongated pulse is then fed into a measuring instrument which records the duration.

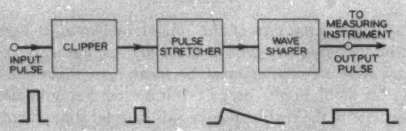

Fig. 1. Block diagram of unit, showing input and output waveforms of each stage

Pulse Stretcher. The stretching circuit utilizes the charge and discharge of a capacitor through a resistor to achieve a linearly proportional output. The pulse stretching circuit is shown in Fig. 2.

The input signal is a positive pulse which is amplified and clipped previous to its application. It is necessary to maintain a constant voltage input for all pulse widths, for the duration of the output is dependent upon the input-signal amplitude.

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Text of the paper awarded second prize in Institute Prize for Best Student Prize Paper contest, and first presented at the District 3 prize paper competition, April 30, 1955.

Arvin Grabel is a student at New York University, New York, N. Y.

Before the signal is applied, both D_1 and D_2 are conducting and there is no current in C. The combination of resistors, R_3, R_1, and the diode resistances, represent a voltage divider. Since R_3 is much greater than the other resistors, the greatest voltage drop appears there. This voltage drop is large enough, so that for practical purposes V_1 can be considered to be zero.

Upon application, the pulse charges the capacitor C_1 according to the relation

$$e_c = E_i(1-\epsilon^{t/RC}),\ 0 \leq t \leq t_1 \qquad (1)$$

where e_c is the voltage across the capacitor, and E_i is the amplitude of the input signal. A time constant is chosen such that, for the allowed range of input pulse widths, the operation is on the linear portion of the exponential charge, as shown in Fig. 3.

At time $t=t_1$, where t_1 is the width of the input pulse, the capacitor begins to discharge. This discharge occurs entirely through R_3 and E, for all other branches represent much higher impedances to the discharge current. The series diode D_1 prevents the capacitor from discharging through R_1. D_1, which is cut off during the discharge, acts as a switch, for it permits current flow through R during the charge, and prevents it during the discharge. The discharge is such that the following relation is satisfied

$$e_c = E_0-(E_0+E)(1-\epsilon^{-(t-t_0)/R_3C}),\ t_1 \leq t \qquad (2)$$

where E_0 is the value of the condenser voltage at t_1, and E is the magnitude of the voltage in the discharge branch. The value of the time constant R_3C is again made large so that the discharge may be assumed to be linear from $e_c=E_0$ to $e_c=0$.

Linearity is obtained by letting the discharge approach a negative potential E. The decay will be approximately linear for one tenth the time constant.

Fig. 5*A* is a graphical representation of obtaining a linearly proportional stretch. The discharge to a negative potential increases the linearity of the discharge curve in the positive region. This is advantageous, for it is simpler to determine the width using $e_c=0$ as a reference than using two values of e_c as references. For accuracy in measurement, a clearly defined waveshape is necessary. If the condenser were to discharge to zero, the intercept of the waveform on the reference axis would be ambiguous. This

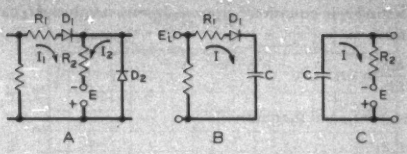

Fig. 4. Equivalent circuits for the conditions present in the circuit

is shown in Fig. 5*B*. The ambiguity would make it impossible, for all practical purposes, to determine the duration accurately.

The return to a negative potential helps define the waveshape, but good definition is more directly related to the shunt diode D_2. When the capacitor voltage is positive, D_2 is not conducting, since the anode to cathode potential is then negative. At some time t_2, the capacitor voltage becomes zero. The diode prevents the capacitor voltage from becoming negative, since it is effectively a short circuit following time t_2. The diode acts as a "baseline clipper," giving a sharp edge to the end of the stretched wave. The output pulse duration may now be calculated. Let t_2 be the time when the shunt diode clips the waveform; t_2 is therefore the duration of the output and can be found by setting $e=0$ in equation 2. The result is

$$t_2 = R_3C\left(\log_\epsilon \frac{E_0+E}{E}\right)+t_1 \qquad (3)$$

Equation 3 is an exact expression for the output duration. Because the operation of the pulse stretcher is linear, the charging of the capacitor approximately obeys the equation

$$e_c = \frac{E_i t}{R_1C},\ 0 \leq t \leq t_1 \qquad (4)$$

This is found by taking the derivative of equation 1 with respect to t at time $t=0$. This relation holds as long as t/R_1C is never greater than one tenth. The error in this approximation at one tenth is 5 per cent, which is within the accuracy required. The discharge also is approximately linear and can be expressed as

$$e_c = E_0-\frac{E_0+E}{R_3C}(t-t_1),\ t_1 \leq t \qquad (5)$$

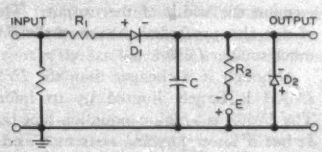

Fig. 2. Pulse stretching circuit

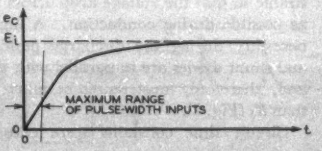

Fig. 3. Exponential charging curve, showing range where linearity can be assumed

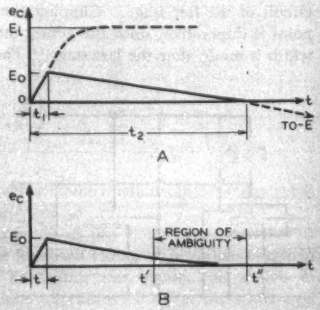

Fig. 5. A—Graphic output pulse is triangular, with each leg being linear, when discharge returns to a negative potential. B—Shape of the output pulse is ambiguous in the region of t' and t''

By letting e_s in equation 5 approach zero, a value of t_2 can be found

$$t_2 = \frac{E_1 R_3}{E R_1} t_1 + t_1 \qquad (6)$$

but $t_2 >> t_1$, and therefore

$$t_2 = \frac{E_1 R_3}{E R_1} t_1 \qquad (7)$$

This equation shows the linear variations of t_2 with t_1. The term E_1R_3/ER_1 is the ratio of t_2 to t_1 and will be called the stretch ratio. This constant may be adjusted to permit a variety of elongation ratios, provided the approximations made are still valid.

Equation 7 illustrates that a linear stretch is obtainable. However, the output waveshape is triangular, and a rectangular pulse is required by existing measuring equipment. Therefore, it is desirable to convert the waveform into a rectangular pulse.

The Waveshaping Circuit. The waveshaper consists of a 5-stage amplifier and clipper. A typical circuit is shown in Fig. 6. The method of obtaining a rectangular wave from the stretcher output utilizes low-level clipping of an amplified wave. In addition to the clipping action, this process tends to increase the slope of the nonvertical edge of a waveform. The clipping in this circuit is accomplished by using plate-catching diodes.

The input to the waveshaper is amplified by the first stage. The plate-catching diode D_c is set so the amplified signal voltage can never exceed a certain prescribed value. This value is never greater than a few volts.

Fig. 7 shows the amplifying and clipping process without regard to the 180° phase shift in the amplifier. The dotted portion of the output represents what the amplified wave would be if there was no clipping. It will be noted that the slopes of the lagging and leading edges have been increased.

The diode clips the waveform at a low level, removing the triangular peak. This process is repeated in each of the following stages. Each stage increases the slope of the lagging edge until the output pulse has a rectangular shape; output is shown in Fig. 8. To eliminate any possible undershoot, baseline clipping diodes are employed in the third and fifth stages. A clipping diode is included in the grid circuit to eliminate undershoot present after the second amplifier. The last clipping diode is inserted in the plate circuit of the last stage. Clipping the undershoot at this point is imperative, since the actual measurement of pulse width is made after the last stage. Theoretically, the unit should operate satisfactorily over the prescribed range if the assumptions made are valid.

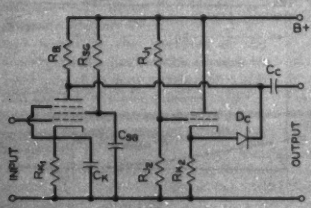

Fig. 6. Typical amplifier and waveshaper

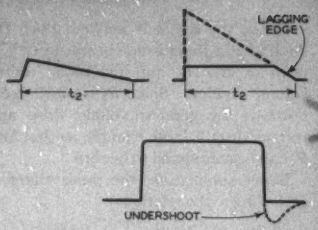

Fig. 7 (top). Method of converting a triangular to a rectangular waveform, utilizing amplification and low-level clipping. Fig. 8 (below). Output waveform

PRACTICAL CIRCUIT

THE PRACTICAL CIRCUIT will be discussed with emphasis on two phases; the first will be concerned with component selection, while the second will deal with the experimental results and their implications. Primarily, the components were selected for the properties of accuracy and stability. However, considerations pertaining to cost, physical suitability, and useful life were never neglected. The experimental results presented herein are based upon measurements made on the final circuit. The method of readout with frequency counters and oscilloscopes is described and the accuracies of the two instruments are compared. The results are compared with theoretical values, and sources of error are noted.

The Choice of Components. Successful operation of the unit is dependent upon close control of diode clipping levels, time constants, the input-pulse amplitude, and certain potentials; realization of such control is contingent upon the selection of suitable components. Measurements were made using components other than those employed in the final circuit. These measurements were not recorded, for it was readily apparent from them that the unit did not satisfy the stated requirements.

Three diodes were tested for use in the unit, the *6AL5*, the *IN34A*, and the *IN56A;* of these the *IN56A* appeared best suited. The *6AL5* was not used because its characteristics are not linear in the region where the voltage is substantially zero. When used as a baseline clipper, therefore, the *6AL5* does not give good definition; the lagging edge becomes round near zero voltage and it is difficult to determine the width of the output. The important factor of size also precluded the use of the *6AL5* in place of the much smaller *IN56A*.

Although it is cheaper than the *IN56A*, the use of the *IN34A* is largely limited by its inferior characteristics. The *IN56A* is a high-conduction-type semiconductor diode. It has a lower forward resistance and higher back resistance than the *IN34A*. A low forward resistance is desirable so that the voltage drop across the diode is as small as possible during conduction. A high back resistance is necessary during the discharge period. Both the series and shunt diodes are in parallel with the discharge branch and, therefore, must represent much higher impedances than R_3 (Fig. 2).

Circuit time constants were chosen to provide dis-

charge curves, displaying a sufficiently high degree of linearity. The most suitable value of time constant to use appeared to correspond to 10 times the longest pulse width. The discharge time constant was chosen with the additional objective of obtaining a linear stretch over the greatest range of pulse-width inputs; it was further desired to make the stretch ratio as large as possible. However, if repetitive pulses are to be measured, the stretch ratio is limited by the pulse repetition rate. If the stretch ratio were made too large, the elongated pulses would overlap, making measurement impossible, as shown in Fig. 9. The optimum value of stretch ratio was found to be 100.

The values of input amplitude and discharge potential E were chosen as +50 volts and −120 volts, respectively. These values were chosen to give the maximum optimum stretch ratio over the widest range of pulse-width inputs. The discharge potential was selected so that overlapping would not occur and the lagging edge would be linear. The input amplitude was made large enough to obtain a large stretch ratio, and small enough so that the waveshaper would not become unduly complicated. The remaining components were selected to maintain the linear relationships.

The Methods of Readout. The specifications of the unit require adaptability to common types of measuring devices. The most widely used of these are oscilloscopes and frequency counters. Frequency counters have the advantage over oscilloscopes of permitting automatic digital readout. However, the method of readout is simple in both cases.

The output of the last stage of the linear pulse stretcher is fed directly into the terminals on the oscilloscope, preferably through a low-capacity probe. The use of a low-capacity probe reduces distortions and attenuation effects so that a clearer picture may be obtained. The pulse width is then read directly on a calibrated time axis. This method provides only two-place accuracy. Narrow-bandwidth oscilloscopes are cheap and compact and, when used with the linear pulse stretching circuit, are capable of measuring the short pulse durations required. Obviously, it serves no purpose to use the stretcher unit with wide bandwidth oscilloscopes, since the duration of pulse widths in question can be determined directly.

The use of the pulse stretcher with a frequency counter involves some additional circuitry. The original input pulse is amplified and fed into the counter. This resultant pulse triggers the counters and starts the measurement sequence. The output of the last stage of the unit, which is a negative pulse, is differentiated and the negative portion of the differentiated wave is clipped at the base by a diode. The result of this is a pulse determined by the lagging edge of the output pulse, as shown in Fig. 10. This pulse is amplified and then used to trigger the counter. This trigger serves to shut the counter off. The process of starting the counting sequence on the leading edge of the input and stopping the sequence on the lagging edge of the output determines the width of the output pulse.

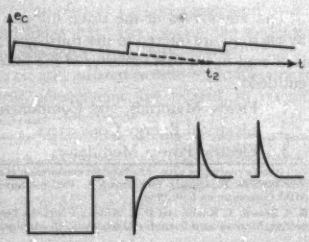

Fig. 9 (top). Effect of pulse repetition rate on the stretch ratio. Fig. 10 (below). Method of obtaining a pulse, based on the lagging edge of the output, to trigger the counter. (left) Output pulse; (center) Differentiated pulse; (right) Triggering pulse

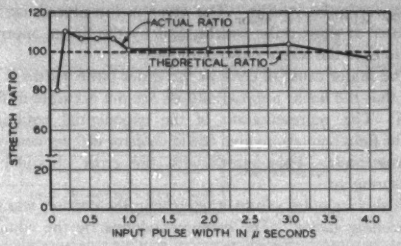

Fig. 11. Performance curve of a linear pulse stretcher

This method is more accurate than that employing an oscilloscope. The error incurred by the counter used in these measurements is 100 times the ratio of the reciprocal of the output pulse width to the known frequency applied to the counter. In the range of inputs encountered, this error is always 10 per cent or less. The use of the counter eliminates the human error in interpolation and permits direct reading to three places.

The Results of Experimental Measurements. The two fundamental relationships which provide the best guide to the proficiency of operation of the linear pulse stretching circuit are stretch ratio and percentage error as functions of the input pulse width. The percentage error is computed using an idealized pulse stretcher, i.e., perfectly linear over the entire range of input pulse width. The values obtained are found in Table I.

Table I. Stretch Ratio and Percentage Error as Functions of Input Pulse Width

Input Pulse Width, Microseconds	Pulse Width Out in Microseconds			Stretch Ratio	Percentage Error
	Ideal	Counter	Oscilloscope		
0.1	10	8.0	9.5	80	20
0.2	20	22	21	110	10
0.4	40	43	42	107	7.5
0.6	60	65	64	108	8.3
0.8	80	86	85	107	7.5
1.0	100	101	102	101	1.0
2.0	200	203	205	101	1.5
3.0	300	313	315	104	4.3
4.0	400	384	380	97.2	4.0
5.0	500	457	455	91.6	8.6

Fig. 11 is a graph showing the relationship between stretch ratio and input pulse width.

The specified accuracy of the linear pulse stretcher is ±10 per cent of the idealized value. The values obtained experimentally all lie within this region. As shown in Table I, the experimental values fell off at the wider and

narrower pulse widths. The error is introduced by the counter at short pulse widths, and by the linear approximations at the wider pulse durations.

The major cause of error at the wider pulse widths is the fact that the linear approximations are not accurate in that area. The representation of the exponential equations by the linear equations give rise to an error of 9 per cent at 5 microseconds. This agrees with the error obtained in measurement.

At shorter pulse widths, the error in the counter was the controlling factor. The error introduced by the counter at input pulse widths below one half of a microsecond is above 4 per cent. This error, the error in the approximations, and the small experimental errors cause the noted deviation from the desired values.

The linear pulse stretching circuit was designed for use with a 1-mc counter, since such a unit is cheaper, lighter, and less complex than similar higher frequency devices. If a 10-mc counter were employed, the error would always be less than 1 per cent.

The error in using the linear pulse stretching circuit has never exceeded the specified 10 per cent, and the unit appears to be well suited to its stated purpose.

SUMMARY AND CONCLUSIONS

THE LINEAR PULSE STRETCHING CIRCUIT provides an effective means of increasing the accuracy of pulse-width measurement of short-duration pulses. Another observation which may be noted is that frequency counters are better suited for pulse-width determination than oscilloscopes because they eliminate the human error in interpolations and provide a digital readout.

The operating characteristics, including weight, cost, adaptability to other pulse circuits, and accuracy in the prescribed region make the linear pulse stretching circuit practical for pulse-duration measurements.

A New Educational Program in Energy Conversion

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The energy-conversion portion of the new electrical engineering curriculum at Massachusetts Institute of Technology is described. The motivation for the curriculum revision is to equip engineers with adequate electrical science to contribute to the advancement of electrical technology in any industry, not merely those normally thought of as electrical.

ELECTRICAL ENGINEERING STUDENTS graduating in June 1955, from the Massachusetts Institute of Technology experienced a new undergraduate curriculum which represented a significant broadening and deepening of the science content of the previous one. The broad scope of the new curriculum was described in a paper by G. S. Brown, entitled "Educating Electrical Engineers To Exploit Science."[1] This second paper elaborates on the substance, organization, and problems of the portion of the new curriculum that treats electrical energy conversion.

The electrical portion of the revised curriculum comprises a group of eight core subjects. Three of them are organized under the broad title of *Energy Conversion* and aim to provide each electrical engineering student with background for an understanding of the conversion, utilization, and control of electrical energy. Each student also studies a parallel sequence of subjects under the general heading of *Information Processing*. The new subjects on energy conversion are not mere substitutes or equivalents for the traditional subjects on a-c and d-c machinery or power transmission. On the contrary, their content recognizes that the imaginative processing of energy is one of the major responsibilities of engineers. The impact of new materials, new environments, new energy sources, new calculating machines, as elements of our new abundance, has increased the breadth, versatility, and depth of scientific competence demanded of tomorrow's engineer. The field of feedback control systems and its growing partner, automation, are but early manifestations of activities that cut through the traditional boundaries between the fields of machinery, electronics, circuit theory, and communications.

ORGANIZATION

THE FIRST TWO of the three subjects in the *Energy Conversion* stem are offered in the third year; the third subject is offered in the first semester of the fourth year. They are entitled:

1. Fields, Materials, and Components
2. Electrical Energy Converters
3. Electric Power Modulators

Full text of a conference paper scheduled for presentation at the Winter General Meeting, New York, N. Y., January 30–February 3, 1956, and approved for publication by the AIEE Committee on Education.

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The four-year electrical engineering curriculum is shown in Fig. 1. As it has evolved, the subject *Fields, Materials, and Components* has emerged as one that prepares students both for the energy-conversion subjects and also for the subject *Energy Transmission and Radiation*, offered in the first term of the fourth year. The discussion in this paper, however, will deal mainly with the subjects called *Electrical Energy Converters* and *Electrical Power Modulators*.

Each subject is operated with a weekly program of lectures, recitations, and laboratory supplemented by outside problem work and reading to use a nominal total of 12 hours of study time per week. A student carrying a full load is expected to devote between 45 and 50 hours per week to his studies. About 150 students comprise each group. A student who commences the *Energy Conversion* sequence at the beginning of his third year will have studied circuit theory for two semesters with Guillemin's *Introduction to Circuit Theory* as a text; basic physics for four semesters, the last two of which use Frank's *Electricity and Optics* as a text; mathematics through differential equations for four semesters; and other subjects as shown. Beginning also in the third year the student studies electronics and advanced calculus, with thermodynamics or atomic and nuclear physics as electives. Each student enters the third year with a strong background in mathematics, and electricity and magnetism as represented by Maxwell's equations. A deliberate effort has been made to synthesize the sequence on energy conversion to utilize this background, and to represent a real intellectual challenge.

The broad pattern of the sequence starts with field theory and relates it to the microscopic concept of materials, continues through the combination of these materials to perform energy-processing functions, treats the basic principles of energy-processing devices, and culminates in the study of energy-conversion systems composed of interconnected devices. The development of this pattern is best seen by tracing through the outlines of the three individual subjects making up the sequence, as presented to the class of 1956.

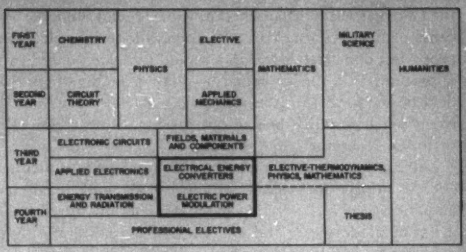

Fig. 1. Representation of the four-year electrical engineering curriculum at MIT

DESCRIPTION OF SUBJECTS

THE FIRST SUBJECT, entitled *Fields, Materials, and Components* treats

1. Vectors and fields
2. Magneto and electrostatic fields
3. Dielectric materials
4. Magnetic materials
5. Energy and forces in static fields
6. Electromagnetic fields

The approach is to emphasize key principles and make generalizations about fields that carry beyond the students' already existing background from second-year physics. Vectors are introduced and utilized to achieve compactness of expression. Field phenomena are related to circuit phenomena through the definitions of resistance, capacitance, and inductance, and some feeling is given of the place for either a field or a circuit approach to a problem. The field concepts are then applied to the understanding of the microscopic or molecular theory of dielectric and magnetic materials, the relationships between microscopic and macroscopic behavior, and the ideas of energy in a field. Finally, the principles of electromagnetic fields are summarized in the form of Maxwell's equations. The laboratory work encompasses exercises on field mapping by various techniques and the study of the dielectric and magnetic properties of materials under changing environments of field intensity, frequency, and temperature.

The content of the second subject, *Electrical Energy Converters*, is

1. Coupled magnetic circuits
2. Magnetic amplifiers
3. Energy
4. Energy conversion
5. Incremental-motion transducers

The purpose is to show how the interactions of fields with materials may lead to methods for controlling and converting energy and how the engineer may realize devices for doing so.

The work in magnetics stems from the fact that devices formed from magnetic materials and exploiting magnetic fields can store, transform, and control the flow of energy. Typical classes of stationary devices are reactors, coupled magnetic circuits, and magnetic switches or amplifiers. The work leads into the conversion of electric energy to mechanical form through the medium of electric and magnetic fields. The conversion process is treated first by study of the reaction forces and voltages exerted by the fields on the participating electrical and mechanical systems during conversion, and second by a study of the overall energy of the system in which the conversion takes place. This latter approach necessitates a careful analysis of what is meant by the co-ordinates of a system, and what can be accomplished by the use of other state functions than energy. The dynamic behavior of the system is approached through the use of Lagrange's equations of classical dynamics, which serve well for systems having energy storage in more than one medium. These concepts are applied to devices having incremental motion as examples of simple energy-conversion devices. For restricted motion, certain of these devices operate linearly and are termed linear reversible transducers; their behavior is then described by analogue circuits, block diagrams, and frequency-response techniques.

At this stage in a student's learning, he can appreciate

the fact that static devices perform their useful function because engineers use fields and configurations to exploit the properties of materials within a boundary. He further can appreciate that the existence of relative motion between field boundaries, with the magnetic material subordinated to the role of forming the fields, is basic to the operation of a motor or generator.

Laboratory exercises include work on magnetics, such as energy storage in reactors, transformers, and magnetic amplifiers; on force-displacement relationships in electromechanical devices; and on analogue circuits and frequency-response behavior of transducers.

The content of the third subject, *Power Modulators*, is

1. Generalized dynamics of energy converters
2. Translational motion power modulators
3. Rotating power modulators
4. Energy-conversion systems

The subject of power modulators deals with the characterizations for the dynamic behavior of electromechanical energy-processing devices, particularly those that can be controlled from a signal which "modulates" the energy flow. The performance of systems in which these devices function is then studied. In this respect, two areas of difficulty appear because of the present state of technology; one is the complexity of analysis of dynamics of nonlinear devices and systems, and the other is the difficulty of determining analytically the dynamic behavior of certain types of rotating power modulators (machines). However, the techniques of handling these system problems are stressed. The solutions are carried to the limits of present-day knowledge so that, for example, the possibilities of computer methods of solution are explored.

The approach to the subject is to stress the control or the dynamics of energy-processing devices. Linear transfer functions are derived where possible and work is carried out in their terms. The treatment of rotating power modulators is based on a circuit-transformation approach utilizing the methods of classical dynamics to obtain the electro-

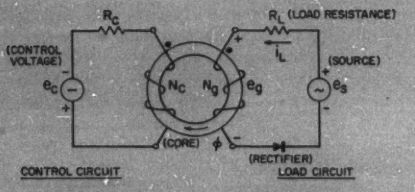

Fig. 2. Single core magnetic amplifier circuit

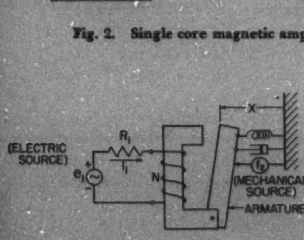

Fig. 3. Singly excited electromechanical transducer

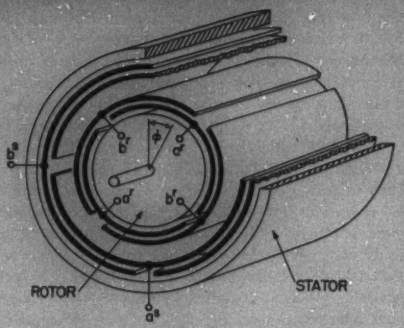

Fig. 4. Generalized two-phase rotating machine

mechanical differential equations for the machine or system. This approach follows the pattern of utilizing classical dynamics that was introduced in the previous subject. The transformation approach is sufficiently general in that it can be applied to nearly all machines, and is highly suitable for students having a strong circuit-theory background. The system work is centered on feedback control systems wherein these energy-processing devices are frequently used.

The laboratory work is concerned with the determination of the parameters and transfer functions of energy-processing devices such as metadynes and servomotors, with measurements on feedback systems, and with a Reeves analogue computer to confirm investigations made in the laboratory.

EXAMPLES

FOUR EXAMPLES from the text material are presented here to illustrate the pedagogical approach. These examples sample perhaps 25 per cent of the content of the second and third subjects. Around these examples are built note material, home problems, and laboratory experiments. These examples typify the use of simple devices whose geometry is sufficiently sophisticated to illustrate the particular set of principles in mind. The associated laboratory experiments may employ practical devices which operate closely in accordance with the action of the idealized model.

Example 1—Single Core Magnetic Amplifier. The single-core magnetic-amplifier circuit shown in Fig. 2 is used as one example in the treatment of magnetics in the subject on electrical energy converters. It serves as a vehicle with which to illustrate a number of concepts. First, it shows how the nonlinear characteristics of a ferromagnetic material can be exploited to realize a device that is able to control the flow of energy over a wide range of values. Also it characterizes the circuit operation of a number of switch-type controllers, such as gaseous-conduction tubes, in which the source voltage is alternately blocked and then applied to the load over each half cycle of source frequency. The example introduces the various requirements of a core used as a switch; for example, the significance of a volt-time integral to secure a flux change, the decoupling of windings by saturation, and the use of a core as a two-state

device. Speaking broadly, the circuit is shown to be a simple building block upon which the technology of more complicated magnetic amplifiers and computer circuits can be built.

The physical operation of the circuit is discussed. The wave forms over a typical cycle of source frequency are examined as the analytical expressions are derived for load current, gate-winding voltage, flux excursion, and so forth. Equivalent circuits are developed for the amplifier in its three states: gating, conducting (saturated core), and reset, as a means for setting up the expressions.

The accompanying laboratory experiment uses the equipment illustrated by Fig. 2. The student is asked to determine, among other matters, the dynamic hysteresis loop of the core, the control characteristics, and the power gain of the amplifier.

Treatment of the simple circuit leads to further work on circuits with nonideal rectifiers; core material, with finite width of the hysteresis loop; pulse transformers; multicore circuits; Ramey circuits; and computer memory circuits.

Example 2—Singly Excited Incremental-Motion Transducer. The simple electromechanical system shown in Fig. 3 is the basis for an example on electromechanical energy conversion in the subject on electrical energy converters.

This device is a simple form of reversible energy-conversion system that can operate between electric and mechanical energy sources. It is a useful structure for illustrating the means whereby energy is transferred from one source to the other through the medium of a common energy-storage space. It illustrates the use of virtual displacement as one suitable method for determining the interaction between the electrical and mechanical systems, and yields the mechanical force expressions which involve rates of change of field energy and coenergy. With these force expressions, differential equations can be written relating the mechanical and electrical variables.

A second use is made of this device by restricting the motions to small values, so that the behavior of the incremental quantities about an operating point can be described by a set of linear differential equations. These equations are solved for the incremental motion of the system under various conditions of driving function. Such operation is characteristic of the use of such a device for transferring information or signals. The electric-circuit analogue of the system can be found in the form of a transfer function and used to compute the response of the system to sinusoidal driving forces.

The third use of this example is to show that the differential equations can be found systematically by using Lagrange's equations. The generalized co-ordinates can be selected as charge q, and position x. The Lagrangian is then found directly from the individual stored energies in the mechanical and electrical parts of the system, or by transformation from the Hamiltonian. Performing the necessary operations on the Lagrangian leads directly to the same equations that were previously obtained by the procedure of equating the system reactions to the two driving functions of voltage and force.

This example serves as a key from which other transducer systems can be considered, examples are the capacitor-type transducer, the transducer with multiple inputs, and the permanent magnet transducer. The laboratory experiment associated with this example is performed on a single-winding, moving-armature voltage regulator called a Regohm. The parameters of the device are measured, and the analogue circuit determined. The frequency response is measured and checked by calculation from the analogue circuit.

Example 3—Generalized Two-Phase Rotating Machine. The generalized two-phase rotating machine shown in Fig. 4 serves as the example upon which much of the theory of continuous electromechanical energy conversion is built in the subject on electrical power modulators. The structure for this example is idealized; it consists of a smooth-surface cylindrical rotor-stator assembly of infinite-permeability material; both members carry two-phase windings which consist of infinitesimally thin current sheets. The current density at any instant of time is assumed to vary sinusoidally with angle ϕ around the periphery of the gap.

The first use of this example is in the determination of the field equations for the air-gap volume in terms of the current densities in the winding sheets and other conditions of rotor velocity and excitation frequency. From these field equations, the power flow in the air gap is studied using the Poynting vector, and the field conditions for energy conversion are established. The self and mutual inductances are obtained by equating the stored energies expressed in field and circuit forms. Some of these inductances are position-dependent or time-varying; hence, lead to circuit equations which have time-varying coefficients.

Solutions to specific problems are obtained by impressing

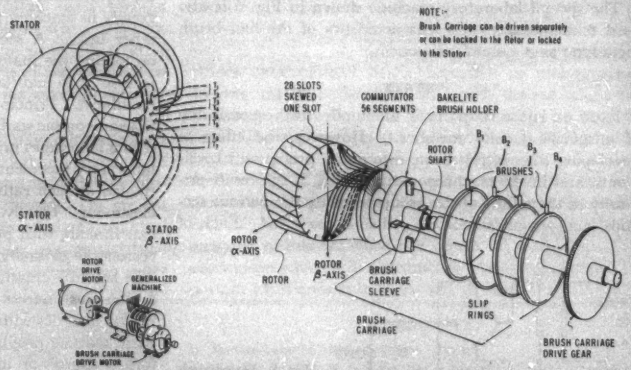

Fig. 5. Laboratory version of the generalized two-phase machine

the required constraints on the electrical and mechanical terminal quantities in the form of interconnections, applied voltages, and torques. Transformations are used to obtain sets of differential equations with non-time-varying coefficients under special conditions, and which are either directly soluble, lead to equivalent circuits, or require a computer type of solution. Thus, this example sets the stage for the consideration of the complete class of rotating-machine problems and solutions.

The laboratory equipment which supports the work on this example is shown in Fig. 5. It is a machine with distributed two-phase windings on both rotor and stator. The rotor windings are connected to a commutator with a motor driven rotatable brush assembly. The purpose for the motor-driven brush assembly is to enable the student to simulate on an actual machine the transformations that are applied to the actual matrix of machine equations. Obviously, the laboratory machine can be operated in all of the modes corresponding to the common types of rotating machines.

Example 4—Four-Brush Metadyne Machines. The metadyne[3] is a suitable example of machines used in energy-conversion systems. A diagram of the four-brush machine is shown in Fig. 6. The specific machine is the generator metadyne with varying degrees of compensation. For zero compensation the machine is an S-generator metadyne and functions as a current source. For full compensation, the machine is an amplifier metadyne and functions as a voltage source. The equations for the four-brush metadyne are obtained by introducing the constraints of the commutator to the matrix for the generalized machine of the previous example. A second set of constraints, based on the field-winding and brush interconnections, yields the equations for the specific machine type. The equations are presented in the form of a block diagram of the machine, or as a transfer function. Both of these presentations are used in the analysis of a system in which the machine is incorporated. The effect of the degree of compensation is studied on the metadyne generator as an element in a system; this leads to a discussion of internal versus external feedback in obtaining prescribed characteristics from devices of this kind.

The special laboratory machine shown in Fig. 6 is also used to demonstrate the characteristics of the four-brush metadyne as a system component.

STAFF

EACH OF THESE SUBJECTS is nominally the responsibility of a specific faculty member. However, the effort of developing the central theme into notes, problems, experiments, and in the teaching and lecturing, is the result primarily of the efforts of the group teaching the various sections, and secondarily of the whole department. Each of these subjects is being given for the class of 1956 in seven recitation sections.

The teams of faculty and junior staff assembled to teach these subjects in their formative stages are drawn from personnel with varied but pertinent backgrounds in order to secure the necessary breadth of viewpoint. For example, one team to teach the subject of electrical energy converters consists of staff members with individual backgrounds in feedback control, magnetics, acoustics, physics, power systems, and circuits. Each staff member has contributed to the lectures and the notes for the portion of the subject that lies within his particular specialty.

The influence of the entire department is felt in these subjects in one of two ways. First, the staff members throughout the department, individually and in committee, have contributed advice, experience, and information. Second, the faculty members have in their graduate subjects the junior staff who teach the laboratory portion, the problem sections, or some of the classes, of these subjects. As a consequence, the substance of these energy-conversion subjects has been distilled from the experience and knowledge of the faculty of the whole department. Since the full responsibility for this curriculum and its further revision will soon rest on the shoulders of the present junior staff, the importance of developing an active junior staff is not taken lightly.

Just as the complementary academic activity of the department strongly influences the content of the new core curriculum, so does the activity in the research laboratories. Contemporary work in the energy conversion laboratory, in the insulation research laboratory, in the servomechanisms laboratory, and in the electronics research laboratory finds its way quickly into the undergraduate curriculum through the experiences in these laboratories of faculty members who also teach, and through the studies and thesis work of the graduate student junior staff.

PROBLEMS AND TRENDS

MANY PROBLEMS remain to be solved as this program evolves. The first is that of finalizing the material sufficiently so that classroom notes can be completed and the information made available as textbooks, thus assisting greatly in teaching this material and releasing key staff for other tasks. A second problem is the usual one of coordinating the material in the various undergraduate subjects so as to maintain a reasonable transition from subject to subject. Principally, this is a problem of communications among the staff. A third problem is that of developing a strong laboratory program to tie in with the classroom. The laboratory represents an effective teaching aid and must be treated as such rather than as a tolerated auxiliary to the classroom. Ideally, the laboratory should mix prescribed experiments with projects so that the student will treat a reasonable diversity of material but on his own initiative. The key to a creative laboratory lies in exciting the imagination and interest of junior staff members who are furnished facilities with which to be creative. It was to make these matters possible that the department abandoned its former courses on machinery and its conventional machinery laboratory facilities. The intellectual challenge of the

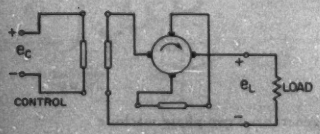

Fig. 6. Four-brush metadyne machine

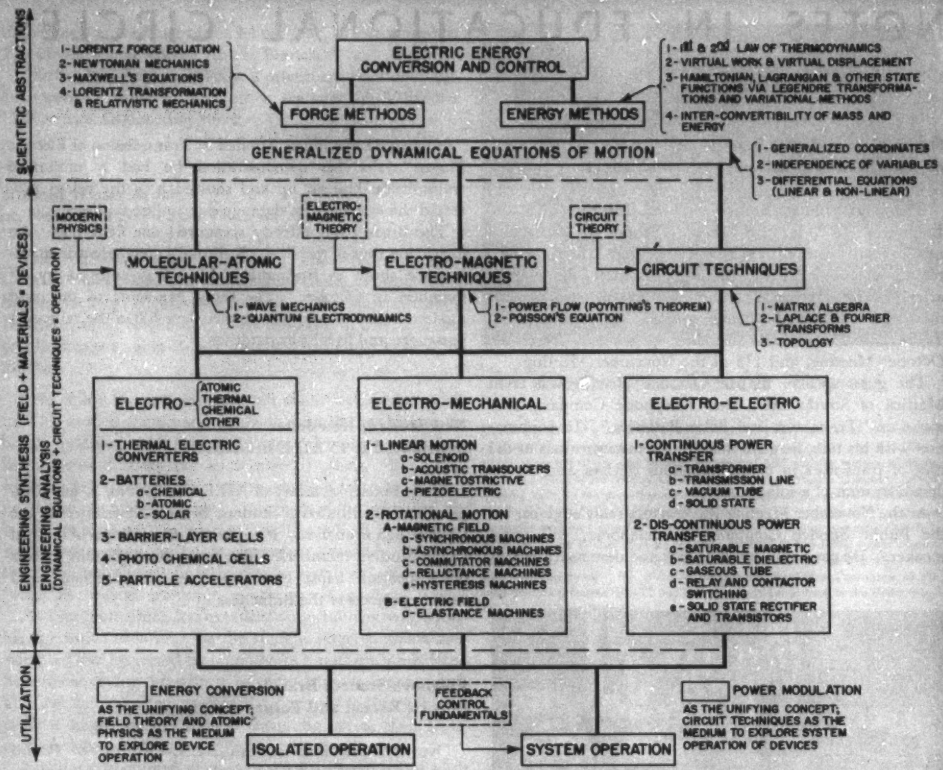

Fig. 7. Interrelations of science and engineering in energy conversion and its utilization

new program has its reward in strong student and staff interest coupled with the discovery that much stimulating work remains to be done and goals to be realized in the energy-conversion field. Research ideas have become plentiful, and funds have become available where a dearth existed before. Actually, the development of this stem of the curriculum has achieved the aspects of a large research endeavor of its own since so much of the material is either new in origin or in presentation.

A fourth problem, and one that may not be solved quickly, is that of attempting to broaden this sequence of subjects to include the study of other forms of energy conversion in which the electrical form is utilized. The present structure of the subjects emphasizes the electromechanical form largely because it is the dominant one in electrical engineering. A subject sequence that includes the other forms of conversion, such as conversion from heat, conversion from light, and conversion from other media, is certainly more in keeping with the spirit of this new curriculum as typified by Fig. 7. The growing importance of other means for conversion of energy to electrical form and the possibility that the energy-conversion field may be revolutionized by a few key developments cannot be ignored. Some progress is being made in introducing this type of material.

CONCLUSIONS

The development of a sequence of undergraduate subjects has been described in which the important area of energy conversion has been presented on a scientific basis. The approach, which is based upon a background of field theory and materials, continues through the study of the marriage of fields with materials to carry out the functions of energy processing, the study of generalized devices, and the behavior of energy-processing systems. The description of this sequence is a report on a segment of the curriculum which will continuously change as new and important ideas appear in the world of science.

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2. Metadyne Statics, J. M. Pestarini, The Technology Press, John Wiley and Sons, Inc., New York, N. Y., 1952.

NOTES IN EDUCATIONAL CIRCLES

Students Attend Meetings of Joint Branch at Missouri School of Mines

The joint Student Branch of AIEE-Institute of Radio Engineers (IRE) at the Missouri School of Mines had near record attendance at its meetings. For its two regular meetings and the September Smoker, the average attendance was over 218. There are now nearly 180 local members and the 200 mark should be reached soon. There were 230 students attending the smoker, 250 at the October Meeting, and 175 at the November Meeting.

The guest speaker for the October Meeting was Irvin Mattick of Southwestern Bell Telephone Company who spoke on "Transistors and Solar Batteries." In conjunction with his talk, he gave numerous demonstrations of the uses of transistors in communications devices and also a demonstration of a solar battery.

At the November Meeting Ray Barton, relay engineer for the Public Service Company of Oklahoma, was guest speaker. He gave an interesting talk and demonstration on "Protective Relaying as Applied to Transmission of Electric Power." For his demonstration he had a miniature transmission line set up and showed how the relays protected the system from damage due to line faults.

The Branch has already sponsored one field trip. An inspection tour of the Frisco Railroad's diesel-electric maintenance shops in Springfield, Mo., was enjoyed by 57 members in October. The shops are some of the most modern in the country and service over 400 of the railroad's passenger and freight locomotives.

▲MEMBERS of the Missouri School of Mines joint Student Branch of AIEE-IRE who participated in the inspection trip to the Frisco Railroad's diesel-electric maintenance shops in Springfield, Mo.

◀GUEST SPEAKER, Ray Barton, relay engineer for the Public Service Company of Oklahoma, demonstrates protective relaying to members of the joint Student Branch of AIEE-IRE at the Missouri School of Mines at the November meeting.

New Student Newsletter Distributed to 15 AIEE Branches

D. R. Boone, secretary of AIEE District No. 2, has compiled and distributed a Student Branch Newsletter to the District's 15 Branches. It contains current items of interest to the Student members. The news items contain reports on inspection trips, guest speakers, competitions, and various projects of the Branches.

Villanova Student Branch Reports Recent and Future Activities

Over 50 members of the AIEE-Institute of Radio Engineers (IRE) Student Branch at Villanova University took the first field trip of the year to the Naval Air Development Center, Johnsville, Pa., last October. Highlights of the tour included the viewing of an immense centrifuge, which subjects objects to gravitational forces rarely experienced, and a demonstration of the 4,000-tube computer which the Development Center uses in solving complex problems. During the month the Branch was host to guest speaker J. W. Lewis of the National Security Agency who spoke on "Magnetic Recording."

In November the joint Student Branch heard three guest speakers from the research department of the Franklin Institute, Philadelphia, Pa., which is known for its museum and planetarium. The speakers were: R. C. Good, physicist; W. W. Felton, mechanical engineer; and H. P. Schick, electrical engineer. Each spoke on the various aspects of engineering research. Members toured the General Electric Switchgear plant in Philadelphia, Pa., for the second field trip of the year.

At the fourth formal Branch meeting of the year in December, J. W. Harte of Brown Instrument Company, Philadelphia, Pa., gave an address on "Instrumentation" and a tour of Brown Instrument's plant was made.

Competition in the second annual AIEE-IRE Pinochle Tournament is well under way. Prizes will be awarded to

the winners at the close of the school year, as announced in *The Circuit*, the newsletter for the Branch.

The Student Branch will take a prominent position in the decorations, displays, and other features of Villanova University's Engineering Week.

Student Writes Article on Need for Prize Paper Contests

The following article entitled, "The Student Paper Contest," was submitted to *Around the Circuit*, a publication by the electrical engineering students of the Massachussetts Institute of Technology. The author, Irwin Dorros, emphasizes the value of entering a student paper contest as follows:

"He knows his stuff, but he can't teach" is an expression used by students time and again to describe an instructor highly qualified in his field, but having virtually no training in methods of conveying knowledge to others. But most students fail to realize that although they have absolutely no desire to make teaching their career, as scientists or engineers they will be required to "teach" all their lives. It is not enough to be a competent, creative thinker. Once an idea, theory, or invention is crystallized, it must be "sold" to the boss, employee, public, or patent office.

As a student, a man has excellent opportunities to develop his expressive abilities. In the student stage, mistakes are tolerated and corrected by members of a staff devoting their lives to conveying thoughts to others. Mistakes are normal and can be corrected painlessly. Once in industry, however, it might be too late to learn the art of intelligent explanation or at least it might be costly to a career.

Making a concerted effort to explain things clearly and at the level of the listening individual or group is a good start, but the opportunity to enter a student technical paper contest is ideal. One can develop an idea that is familiar and gain recognition of the group. In preparing the talk, necessary confidence can be acquired by preparing notes, illustrations, etc., and the problem of making one's self understood is brought into sharp focus. As an example, in projecting the self to the audience, one might think of the many lectures or talks endured and realize that a common fault of many speakers, especially technical ones, is that of beginning at the level of the speaker's familiarity with a subject. The audience may be composed of persons with high ability, but they must have the necessary preparation or "review" to make the transition to the domain of the specific topic.

By entering one contest, immeasurable experience and confidence may be gained by noticing one's own strong points and faults as well as those of the other speakers. How did the speaker begin? How well was he prepared? How well organized was his presentation? Could he be understood easily? Did his demonstrations drive the points home? Did he handle the discussion well? The rules of good speaking are simple, but only experience can develop poise and confidence.

Although most of us hope to win at anything we under-

Computer Center Project

PRESENTATION of a check for $100 to A. H. Waynick, head of the department of electrical engineering at The Pennsylvania State University, by R. L. Sherwood, chairman of the joint Student Branches of AIEE and the Institute of Radio Engineers (IRE), at the Branch meeting in November. A new Computer Center is being built by the department of electrical engineering at The Pennsylvania State University. The department already has in operation an analogue computer and has practically finished building a digital computer, which is expected to be in operation by March. In order to teach the power courses more effectively, a network analyzer was proposed and the department has been seeking funds. The students, through the Executive Committee of the joint Student Branches of AIEE and IRE, contributed the check to the department to aid in securing this project.

AIEE Membership Contest

NEW MEMBERSHIP CONTEST, sponsored by the AIEE San Francisco Section, started in December with nine applications being submitted during the first two weeks. C. Stivers, membership committee chairman, presents an award to Marvin Moler who turned in two applications, while Section Chairman Whitman Ridgway looks on approvingly. Goal of the contest is the addition of 200 new members. An award of a free dinner, or equivalent, at a regular meeting is made for each two applications. A grand prize of $50 will be awarded to the member submitting the greatest number of new applications

take, and feel if we are not qualified to win we should not begin, entering a technical paper contest should be treated differently. It would be most commendable to be first in a contest of this sort, but the experience of standing before a group and talking about something familiar (the specific topic is unimportant) and getting public reaction is most important. Remember, the winner gains less than the man who gains confidence.

Summary of Activities by the Norwich Student Branch

The Norwich University Student Branch was active during 1955 in the Northeast District Student Branch Membership Competition. Norwich University shared honors with Maine and New Hampshire for the largest AIEE membership among the senior class. All three institutions had 100 per cent student membership. In over-all membership Norwich led with 57 per cent, New Hampshire had 56 per cent, and Vermont was third with 39 per cent. The Norwich Branch will use its prize money, totalling $55, to help defray expenses of members attending the Vermont Subsection and other AIEE meetings.

The Branch has just become a joint AIEE-Institute of Radio Engineers (IRE) Branch. Present AIEE officers will serve out their terms as officers of the joint Branch. This has increased interest in Branch activities, with 150 per cent of the senior class and 127 per cent of the juniors belonging to either group. A total of 18 are members of AIEE and 12 of IRE. (It is apparent from these figures that half the seniors and several juniors are members of both.)

Recently 22 members of the joint Branch participated in an inspection trip to a turbine generating station of Green Mountain Power Corporation at Burlington, Vt. The trip was under the auspices of the Vermont Subsection of AIEE.

Four meetings of the Branch have been held to date; the most interesting and successful featured a talk by H. C. Anderson, manager of market research and product planning in the atomic power equipment department, General Electric Company. Mr. Anderson discussed "World Energy Needs and the Atom."

Student Branches Sponsor College Engineering Open House

Demonstrations and exhibits covering many aspects of the engineering profession were the features of the engineering open house at Union College, Schenectady, N. Y., in

District 7 Student Committee

IN NOVEMBER the Student Activities Committee of District 7 held its Fall Meeting at the Skirvin Hotel, Oklahoma City, Okla. One of the important items planned was the Student District Paper Contest to be held in conjunction with the South West (7th) District Meeting in Dallas, Tex., in April. Attending the meeting were, front row, left to right: R. F. Danner, member, Committee on Student Branches; W. B. Morton, chairman, Committee on Student Branches; S. M. Sharp, vice-president, District 7; M. R. Johnson, Jr., chairman, District 7 Student Activities Committee; N. F. Rode, counselor, Texas A & M College; E. L. Sitz, counselor, Kansas State College. Second row: P. E. Pfeiffer, counselor, Rice Institute; Bryan Webb, counselor, University of Arkansas; W. P. Smith, counselor, University of Kansas; J. L. Ellis, counselor, University of New Mexico; C. D. Crouno, counselor, New Mexico College of A & M Arts; J. C. Hogan, counselor, University of Missouri; C. J. Grimm, counselor, Missouri School of Mines and Metallurgy. Back row: F. W. Tatum, counselor, Southern Methodist University; Wendell Fowler, member, Committee on Student Branches; C. L. Farrar, counselor, University of Oklahoma; O. A. Boyer, chairman, Corpus Christi Section; T. B. Stenis, counselor, Texas Technological College; W. E. Ray, counselor, Oklahoma A & M College; J. W. Rittenhouse, member, Committee on Student Branches.

▲OPERATING the "Jacob's Ladder" or "Horned Gap" demonstration of high-voltage electricity for onlookers is Douglas Buddenhagen, a senior electrical engineering student at Union College, Schenectady, N. Y., at the Student Branch AIEE sponsored open house.

◀INSPECTING THE DEMONSTRATION of oscillographic presentation of handwriting, Professor H. Bibber (second from left), member of the teaching staff of the electrical engineering department at Union College, Schenectady, N. Y., with students and guests at the annual engineering open house program. This exhibit was one of many sponsored by the AIEE Student Branch at the open house.

October. Sponsored by the Student Branch of the AIEE together with the Student Branches of the American Society of Civil Engineers and American Society of Mining and Metallurgical Engineers, the program included a display of much of the apparatus used in the laboratories at the college.

The electrical engineering part of the show included an experiment demonstrating lightning protection for homes; an operating television receiver with components arranged in bread-board fashion for visual inspection; a direct current oscillating motor-generator set; an electrical slide rule operated by Selsyn motors; and numerous other electrical and electronic devices.

An annual event, the open house was attended by area high school students, members of the Schenectady Section of the AIEE, and other area residents. This occasion is especially significant at Union College, as engineering has been a regular part of the curriculum since 1845. The program was established by the college's great 19th Century president, Eliphalet Nott, and has attracted many distinguished men to the campus, among them the electrical wizard Dr. Charles P. Steinmetz.

On Friday, February 17, 1956, the AIEE Student Branches of Union College and Rensselaer Polytechnic Institute will hold a joint meeting in Troy, N. Y., to hear C. N. Hoyler of the Radio Corporation of America, Princeton, N. J. Mr. Hoyler will present demonstrations of new developments in electronics, including color television.

Joint Student Branch Active at Texas Technological College

The joint AIEE-Institute of Radio Engineers Student Branch of Texas Technological College in Lubbock, Tex., with 150 members sponsored and built a float for the Annual Homecoming Parade in November. The Branch also took a tour of the local television station, KCBD-TV.

Other activities of the Branch included an annual program during which scholarships were presented to the following three electrical engineering students for outstanding achievements: H. R. Kerby, awarded by Texas Electric Service Company; E. H. Johnson, awarded by Magnolia Petroleum Company; and S. E. Estes, awarded by Southwestern Public Service Company.

Students at Michigan State To Study Factory Procedures

The Maytag Company of Newton, Iowa, has been "adopted" by the engineering department of Michigan State University (MSU), East Lansing. More specifically, an automatic washer subassembly has been adopted, to be used as problem material for a planned integrated sequence of engineering courses for seniors in industrial engineering at the school. The course will cover standard subject matter, but instead of theoretical material the students will be using "live" material—facts and figures as they actually exist at The Maytag Company.

Using this "problem-centered" approach, the students will take time and motion study, plant layout and materials handling, process and tool design, production planning and control, statistical quality control, job evaluation, wage administration, and engineering economics. However, the textbook in their "living laboratory" will be data concerning the automatic washer clutch assembly.

Four MSU professors were in Newton recently gathering data and taking movies of the various operations involved in the clutch assembly and in the mercury switch assembly,

SELECTION of a Maytag subassembly for Michigan State University, East Lansing, was made by four professors gathering material for use in a new integrated sequence of engineering courses based on actual industrial situations. Seated around the table with J. F. Biggane, Maytag chief industrial engineer (second from left), are: professors W. P. Smith, Dale Jones, Jim Thorson, and Jim Apple examining an automatic washer clutch assembly. The others, members of the Maytag industrial engineering staff, which co-ordinated the educators' visit, are, from left: Wayne Creagan, supervisor of work simplification; Richard Burdick and Lavern Matson, supervisors of incentives; and Lewis Oster, engineer.

which will be studied too. They met The Maytag Company's top management, toured the Newton plants, and conferred with representatives of such departments as tool engineering, methods, production control, accounting, research, service, industrial relations, and inspection and quality control. The visit was co-ordinated by the Maytag industrial engineering department. Prints of parts, operation analysis sheets, labor standards, layouts, and sample cost-reduction reports on the areas were acquired and will be incorporated into the course.

Students in the course will have on hand samples of the clutch and mercury switch assemblies, plus samples of each component at each stage of manufacture, from raw material to finished part. In the course of study, the tyro engineers at MSU may even discover better ways of doing things than the methods now in use at Maytag. In any case, they will know a lot about the clutch assembly in a Maytag automatic washer.

Carnegie Tech Branches Sponsor Employment Series in Engineering

The Carnegie Institute of Technology Branch of the AIEE-Institute of Radio Engineers (IRE) in conjunction with the American Society of Mechanical Engineers Student Branch is sponsoring an informative series on employment. These programs are designed to give the prospective engineer an idea of the type of work expected in various fields such as power, atomic energy, electronics, computer, aircraft, railroad, steel, electric machines and appliances, sales engineering, production, research and development, consulting, etc.

Inasmuch as there are only about seven of these joint meetings annually, it is impossible to cover the entire list in any one year, so the programs are planned for a three-year period. In this way, a student who starts attending meetings in his sophomore year can get an over-all picture of an engineer's work in the different industries.

In 1954–55 there were programs on the packaging and processing industries, sales engineering, and the by-products industry. So far, in the 1955–56 academic year the programs have been on the atomic industry, the aircraft industry, and Government employment. In coming months, the Branches will sponsor talks on the consulting engineer, and research and development. Also, the head of the placement bureau and the dean of students will explain employment procedure and professional registration in one of the programs. Each session has a question and answer period. This plan has been very successful, with attendance ranging from 50 to 100 students.

Tour Made by Student Branches of Louisiana State University in October

On October 20, 1955, at 7 p.m., members of the Louisiana State University (LSU) AIEE-Institute of Radio Engineers (IRE) joint Student Branch together with the LSU American Society of Mechanical Engineers (ASME) Student Branch made a tour of the Southern Bell Telephone and Telegraph offices and equipment in Baton Rouge, La.

After a brief orientation, students were divided into groups of approximately 10 members. An employee was placed in charge of each group and the tour began. The

AT A RECENT INSPECTION TRIP of the Southern Bell Telephone Company, members of the Louisiana State University Student Branches observed an incoming television program from the Baton Rouge, La., network and the monitoring equipment. The city is served by microwave from New Orleans.

members saw the power equipment in use and the stand-by power equipment for emergency use. Leaving the power section the groups viewed the relays that select different circuits, the telegraph equipment, the switchboard, and the microwave equipment, part of which is used to receive television from New Orleans, La. A lecture on "Microwave and Transistor Applications" followed. The many advantages of transistors over vacuum tubes were emphasized. Included in the lecture, was a demonstration of a portable transistorized radio transmitter and receiver. A question and answer period ended the lecture.

Refreshments were served in the cafeteria of the building. Members discussed observations made during the tour. The tour was formally concluded at 10 p.m.

INSTITUTE ACTIVITIES

DALLAS SKYLINE

AIEE South West District Meeting To Be Held April 2–4 in Dallas, Tex.

IN THE AREA that produced the B-36 *Cutlass*, and a myriad of electronic controls for aircraft, the AIEE will hold its South West District Meeting at the Baker Hotel, Dallas, Tex., April 2–4, 1956.

The city of Dallas with its skyscrapers and beautiful residential areas is a remarkable city of contrasts, where big industry and agriculture meet on common ground. Dallas, a fashion and apparel manufacturing center of the Southwest, has 550 firms engaged in the oil production industry.

Opening Session and Technical Program

D. A. Quarles, Secretary of the United States Air Force, is scheduled to give the main address at the opening general session on Monday, April 2, at the Baker Hotel.

P. G. Wallace, program chairman, and Felix Quirino, vice-program-chairman—aircraft, have arranged a varied program offering a wide choice of sessions on power generation, transmission and distribution, industry applications, communication, management, aircraft, and aircraft applications.

Especially featured will be power generation sessions on super-critical, high-pressure steam turbines and intercooled generators, and a progress report on nuclear power generation. There will be several management sessions and outstanding consultants in the electrical industry will be present.

Aircraft Technical Conference

The 1956 Technical Conference on Aircraft Electrical Applications will be held in conjunction with the South West District Meeting which has as its theme, "Electricity in Aircraft." Of special interest will be an exhibit of aircraft electrical equipment, allowing those attending the Conference an opportunity to view the latest products of the various exhibitors. The South West District encompasses an extensive and varied aircraft industry. The theme "Electricity in Aircraft" was selected in recognition of the increasing number of electrical engineers in this rapidly expanding industry. The meeting will attract electrical engineers in the aircraft industry from all parts of the United States and from Latin America.

The Committee on Air Transportation will sponsor the technical sessions on aircraft applications. Featured will be papers dealing with the problems of designing electrical and electronic equipment for supersonic, high-altitude aircraft, and guided missiles.

Hotel Accommodations

Blocks of rooms have been set aside at the Baker, Adolphus, and Statler-Hilton Hotels for members and guests. To obtain their reservations without delay or possible disappointment write directly to the hotel of your choice and mention that you are attending the South West District Meeting of AIEE.

Inspection Trips

E. W. Rogers has made arrangements for six inspection trips during the meeting. These trips will be to Bell Aircraft Corporation, Texas Instruments, Chance Vought Aircraft, Dallas Power and Light Company's Parkdale power plant, Southwestern

NEW HELICOPTER, Bell Aircraft Corporation's model 47-H-1, for passenger travel.

Bell Telephone Company's Haskell Avenue Toll Center, and the Republic National Bank Building.

Ladies Activities

A suite for informal gatherings of the ladies will be provided at the Baker Hotel. Coffee will be served each morning after breakfast. Cards and tables will be provided for canasta and bridge. On Monday morning, April 2, the ladies will be entertained in one of the glamorous ballrooms of the new Statler-Hilton Hotel. This will be a "Get-Acquainted Coffee" at 9:30 a.m. On Tuesday at 10 a.m., a brunch and fashion show is planned in the beautiful Zodiac Room at Neiman-Marcus. Both Monday and Tuesday afternoons are left unscheduled so that the ladies may shop, see "Cinerama Holiday," visit the new public library, or the new Republic National Bank. On Wednesday at 9:30 a.m. the ladies will board buses at the Baker Hotel and travel to the Dallas Athletic Country Club for a book review and luncheon. In the afternoon there will be a tour of the city.

Transistor Circuits Conference Scheduled February 16–17 in Philadelphia

THE TRANSISTOR CIRCUITS Conference is scheduled for February 16–17, 1956, at the University of Pennsylvania. The Conference is sponsored by the AIEE, Institute of Radio Engineers, and the University of Pennsylvania. Registration and hotel reservation forms may be obtained from C. W. Hargins, the Franklin Institute Laboratories, 20th St. and Benjamin Franklin Parkway, Philadelphia 3, Pa. The tentative program is as follows:

Thursday, February 16

8:00 a.m. Registration at the Irvine Auditorium

9:30 a.m.–12:00 Noon. Session I on Special Circuits at the Irvine Auditorium

Chairman: P. L. Bargellini, University of Pennsylvania

1.1 Audio Automatic Volume Control Circuit. *B. D. Griffith, J. Tom* (U. S. Army), Radio Corporation of America, Camden

1.2 Linear Amplifier Employing Nonlinear Amplification. *R. F. Grantges, J. Holzer,* Signal Corps Engineering Laboratory, Fort Monmouth

1.3 Voltage-Tuned Networks Using Junction Diodes. *C. R. Hurtig,* Massachusetts Institute of Technology

1.4 Multiterminal Semiconductors Operated as Two-Terminal Source-Free Switching-Devices. *Abraham Herl,* University of Pennsylvania

9:30 a.m.–12:00 Noon. Session A Tutorial at the University Museum

A.1 Analysis and Equivalent Circuits. *R. B. Adler,* Massachusetts Institute of Technology

A.2 Switching Circuits. *R. H. Baker,* Lincoln Laboratory, Massachusetts Institute of Technology

12:00 Noon–2:00 p.m. Lunch at Houston Hall

2:00 p.m.–2:30 p.m. Formal Opening of Conference at the Irvine Auditorium

G. L. Haller, Chairman of Conference
D. G. Fink, Past Chairman of Conference
J. G. Brainerd, University of Pennsylvania

2:30 p.m.–5:30 p.m. Session II on Switching Circuits at the Irvine Auditorium

Chairman: H. E. Tompkins, Burroughs Corporation, Paoli

2.1 Direct-Coupled Transistor Logic Circuitry in Digital Computers. *J. R. Harris,* Bell Telephone Laboratories, Murray Hill

2.2 Transistor Requirements for Direct-Coupled Transistor Logic Circuits. *J. W. Easley,* Bell Telephone Laboratories, Murray Hill

2.3 Junction Transistor Switching Circuits for High Speed Digital Computer Applications. *G. J. Prom, R. L. Crosby,* Sylvania Electric Products, Inc., Waltham

2.4 Circuit Properties of the Conjugate-Emitter (Hook-Collector) Transistor. *J. J. Suran,* General Electric Company, Syracuse

2.5 High Speed Transistor Computer Circuits. *S. T. Weng, A. K. Rapp,* Philco Corporation, Philadelphia

2:45 p.m.–5:30 p.m. Session B Tutorial at the University Museum

A.3 Low Frequency Circuits. *F. D. Waldhauer,* Radio Corporation of America, Camden

A.4 High Frequency Circuits. *J. B. Angell,* Philco Corporation, Philadelphia

6:00 p.m. Cocktail-Buffet at the Penn Sherwood Hotel

7:00 p.m. Informal Group Discussions at the Penn Sherwood Hotel

Friday, February 17

8:30 a.m. Registration Opens

9:00 a.m.–12:00 Noon. Session III on Small Signal Amplifiers at the Irvine Auditorium

Chairman: R. H. Mattson, Bell Telephone Laboratories, Murray Hill

3.1 Transistor D-C Amplifiers. *J. W. Stanton,* General Electric Advanced Electronics Center at Cornell University

3.2 Transistor Amplifier Performance. *J. F. Gibbons,* Stanford University

3.3 Behavior of Noise Figure in Junction Transistors Over Their Useful Frequency Spectrum. *E. G. Nielsen,* Bell Telephone Laboratories

3.4 A Carrier-Frequency Transistor Feedback Amplifier. *D. A. DeGraaf, F. H. Blecher,* Bell Telephone Laboratories, Murray Hill

3.5 The Design of Bridge-Derived Circuits for Precision Control of Transistorized Amplifiers. *W. S. Chaskin, V. Babin, I. Gottlieb,* Lenkurt Electric Company, Inc., San Carlos

12:00 Noon–2:00 p.m. Lunch at Houston Hall

2:00 p.m.–4:30 p.m. Session IV on Power Amplifiers and Power Supplies at the Irvine Auditorium

Chairman: G. H. Royer, Westinghouse Electric Corporation

4.1 Temperature Effects in Circuits Using Junction Transistors. *H. G. Lin, A. A. Bova,* Radio Corporation of America Laboratories, Princeton

4.2 Design Considerations for Semi-Conductor Regulated Power Supplies. *S. Sherr, P. Lacy,* General Precision Laboratory, Pleasantville

4.3 The Design of Transistor DC to DC Transformers for a High Degree of Reliability and Stability. *V. M. Thompson,* Canadian Defence Research Establishment, Ottawa

4.4 Single Power Transistor DC-DC Converter. *D. A. Paynter,* General Electric Company, Syracuse

4.5 Characteristics and Circuit Applications for a New Type Power Transistor. *J. F. Marshall,* Minneapolis-Honeywell Regulator Company, Minneapolis

Conference on Instrumentation To Be Held in Boston April 26–27

The AIEE Recorders and Controllers Conference on New Developments in Instrumentation for Industrial Control will be held at the Hotel Bradford, Boston, April 26–27, 1956. The following topics listed as potential papers have been conceived by the Conference Committee. The final selection of manuscripts to be presented will be decided by the Conference Papers Review Committee, based on quality and timeliness. The closing date for Conference Papers is February 24th.

Introduction to Technical Program:

R. J. Jeffries, Schlumberger Instrument Company

Session I—Information Display and Recording

Chairman: P. A. Borden, Ret., Bristol Company

Human Engineering in Industrial Information and Control Systems

The Dynamics of Electronic Self-Balancing Systems

Recent Developments in Information Display and Recording: A New Type Recorder Mechanism; A New Concept in Display and Recording, and Instantaneous Cathode-Ray Digital Display

Chairman: A. J. Hornfeck, Bailey Meter Company

Session II—Automatic Data Handling Systems

Modern Scanning, Monitoring, Display and Circuitry Techniques in Plant Data Systems

Analogue-to-Digital Conversion; Telemetering Needs and Techniques for Modern Production and Research

New Developments and Trends in Analogue-Digital Industrial Data Systems

New Developments in Radio Telemetry Systems

Session III—Advanced Instrumentation Systems in Industry

Chairman: W. H. Howe, Foxboro Company

Transducer-Transmitters for Modern Data Systems

Advanced Data System in the Atomic Industry

Advanced Data System in the Aircraft Industry

Advanced Data System in the Chemical Process Industry

Session IV—Computer-Controlled Systems for Industry

Chairman: J. W. Percy, United States Steel Corporation

Operations Research and Computer-Control

Optimized Utility Operations

Suggestions for Self-Determining Computer-Control Systems

Solid-State Devices Versus Tubes for Computer-Controlled Systems

Western Computer Conference Will Be Held February 7–9 in California

THE WESTERN COMPUTER Conference is to be held in San Francisco, Calif., February 7–9, 1956, at the Fairmont Hotel. The tentative technical program for the conference is as follows:

Tuesday, February 7

Morning Session—Opening Addresses

Keynote Address: *N. H. Taylor*, Lincoln Laboratories, Massachusetts Institute of Technology

Electronics in Army Support Operations. *Brigadier General W. B. Large*, chief, Army Communications Service Division; *Harold Silverstein*, special assistant to chief signal officer; *Captain Benedict Jacobellis*, systems planning officer

Afternoon Session I—Programming and Coding

Gestalt Programming: A New Concept in Automatic Programming. *D. T. Ross*, Servo Laboratories, Massachusetts Institute of Technology

A Truly Automatic Computing System. *Mandalay Grems, R. E. Porter*, Boeing Airplane Company

Lincoln Laboratory Utility Program System. *H. D. Benington, C. H. Gaudette*, Massachusetts Institute of Technology

An Automatic Supervisor for the IBM 702. *Bruce Moncreiff*, Rand Corporation

Afternoon Session II—Accessories

Magnetic Recording Head Design. *A. S. Hoagland*, University of California, Berkeley

A Terminal for Data Transmission over Telephone Circuits. *W. D. Lewis*, Bell Telephone Company

The Use of the Charactron with an ERA 1103. *Ben Ferber*, Convair

A New Magnetic Tape Handler for Computer Applications. *R. M. Brumbaugh*, Ampex

Evening—Cocktail Party

Wednesday, February 8

Morning Session III—Description and Design

Engineering Design of a Magnetic Disk Random Access Memory. *T. Noyes, W. E. Dickinson*, International Business Machines

The System Organization of the IBM 305. *M. L. Lasser, J. W. Haanstra*, International Business Machines

Program Interrupt on the Univac Scientific Computer. *J. Merrel*, Remington-Rand

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Morning Session IV—Systems

A Pulse Duration Modulated Data Processing System. *John Lowe, Jack Middlekauff*, Douglas Aircraft

A PDM Data Converter. *W. R. Arsenault*, Magnavox

An Improved Multichannel Drift-Stabilization System. *P. G. Patsantzis*, Massachusetts Institute of Technology

Combined Analogue and Digital Computing Techniques for the Solution of Differential Equations. *P. A. Hurney*, Massachusetts Institute of Technology

Noon—Luncheon

Afternoon Session V—Design, Programming and Coding

An Experimental Monitoring Routine for the IBM 705. *H. V. Mook*, Hughes Aircraft

Logical Design of a Digital Computer for a Large-Scale Real-Time Application. *Astrahan, Hosman, Jacobs, Mayer, Thomas*, International Business Machines

Computer Design To Facilitate Linear Programming. *R. C. Gunderson*, Remington Rand

Considerations in Making a Data-Processing System Computer Compatible. *B. L. Waddell, W. R. Kling*, Gianini

Afternoon Session VI—Applications

Using a Variable Word Length Computer for Scientific Calculation. *Fred Gruenberger*, General Electric

Unusual Problems and Their Solutions by Digital Computer Techniques. *Lawrence Rowenfeld*, Melpar, Inc.

A Progress Report on Computer Applications in Computer Design. *S. R. Gray, R. H. Kisch*, Remington Rand

A Topological Application of Digital Computing Machines. *Asher Opler*, Dow Chemical

Thursday, February 9

Morning Session VII—Applications

Applications of the Small Digital Computer in the Aeronautical Industry. *H. M. Livingston, Edgar L. Lyons*, Burroughs Corporation

Traffic Simulator with a Digital Computer. *S. Y. Wong*, Philco Corporation

Integrated Data Processing with the Univac File Computer. *R. P. Daly*, Remington Rand

A Fixed Program Data Processor for Banking Operations. *Jack Goldberg*, Stanford Research Institute

Session VIII—Circuits

A One-Microsecond Adder, Using One-Megacycle Circuitry. *A. Weinberger, J. L. Smith*, National Bureau of Standards

Bilateral Magnetic Selection Systems for Large-Scale Computers. *A. H. Sepahban*, Philco Corporation

Megacycle Magnetic Amplifiers. *T. H. Bonn*, Remington Rand

Afternoon Session IX—RCA "Bizmac" System

Purpose and Application of the RCA Bizmac System. *W. K. Halstead, J. W. Leas, J. N. Marshall, E. E. Minett*, Radio Corporation of America

Functional Organization of Data in the RCA Bizmac System. *A. D. Beard, W. K. Halstead, J. F. Page*, Radio Corporation of America

The System Central Concept in the RCA Bizmac System. *J. A. Brustman, P. T. O'Neil, J. L. Owings*, Radio Corporation of America

Characteristics of the RCA Bizmac Computer. *A. D. Beard, L. S. Bensky, D. L. Nettleton, G. E. Poorte*, Radio Corporation of America

Programming the Variable-Item-Length RCA Bizmac Computer. *L. S. Bensky, T. M. Hurwitz, A. S. Krausley, R. A. C. Lane*, Radio Corporation of America

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Nonlinear Control Systems Conference To Be Held in March

The joint AIEE-American Society of Mechanical Engineers (ASME) Conference on Nonlinear Control Systems will be held at Princeton University, Princeton, N. J., March 26–28, 1956. The AIEE sponsoring committee will be the Feedback Control Systems Committee, and the ASME sponsoring group will be the Instrument and Regulator Division.

The papers to be presented on this Conference will be on basic and new methods for analysis of nonlinear control systems, practical systems with inherent nonlinearities, theoretical and computer studies of so-called optimum relay servomechanisms, and synthesis methods for nonlinear systems.

Serving on the Program Committee: R. E. Clarridge, W. I. Caldwell, R. M. Hutchinson, and Chairman T. M. Stout

Scintillation Counter Symposium To Be Held in Washington, D. C.

The Fifth Scintillation Counter Symposium will be held February 28–29, 1956, at the Shoreham Hotel, Washington, D. C. Sponsors of this Symposium are the AIEE, Institute of Radio Engineers, National Bureau of Standards, and the Atomic Energy Commission. There will be four daytime sessions covering the following areas: Photomultipliers and Circuits, Scintillators, Particle Detection and Scintillators, and Special Problems and Techniques. An evening forum will be held February 28th for the discussion of scintillation counter problems. The international situation with respect to scintillation counters and photomultipliers will be reviewed at this forum.

Future AIEE Meetings

AIEE-IRE-ACM Western Computer Conference
Fairmont Hotel, San Francisco, Calif.
February 7–9, 1956
(*Final date for submitting papers—closed*)

AIEE-IRE University of Pennsylvania Transistor Circuit Conference
University of Pennsylvania
Philadelphia, Pa.
February 16–17, 1956
(*Final date for submitting papers—closed*)

Scintillation Counter Conference
Shoreham Hotel, Washington, D. C.
February 28–29, 1956
(*Final date for submitting papers—closed*)

Southern Textile Conference
Georgia Institute of Technology, Atlanta, Ga.
March 1–2, 1956
(*Final date for submitting papers—closed*)

Paper and Pulp Conference
University of Florida, Gainesville, Fla.
March 8–9, 1956
(*Final date for submitting papers—closed*)

AIEE-ASME Fourth Annual Engineering Management Conference
Hotel Statler, St. Louis, Mo.
March, 14–15, 1956
(*Final date for submitting papers—closed*)

AIEE, Illinois Institute of Technology American Power Conference
Sherman Hotel, Chicago, Ill.
March 21–23, 1956
(*Final date for submitting papers—closed*)

AIEE-ASME Nonlinear Controls Conference
Princeton University, Princeton, N. J.
March 26–28, 1956
(*Final date for submitting papers—closed*)

South West District Meeting
Baker Hotel, Dallas, Tex.
April 2–4, 1956
(*Final date for *TP—closed, ‡DP Syn.—closed DPMs—Feb. 2*)

AIEE-IRE-ISA Magnetic Amplifiers Conference
Syracuse Hotel, Syracuse, N. Y.
April 5–6, 1956
(*Final date for submitting papers—closed*)

Rubber and Plastics Conference
Mayflower Hotel, Akron, Ohio
April 9–10, 1956
(*Final date for submitting papers—closed*)

Great Lakes District Meeting
Fort Wayne, Ind.
April 16–18, 1956
(*Final date for *TP—closed, ‡DP Syn.—Feb. 1 DPMs—Feb. 16*)

AIEE, ASME, ISA Recording and Controlling Instruments Conference
Bradford Hotel, Boston, Mass.
April 26–27, 1956
(*Final date for submitting papers—closed*)

AIEE-IRE Electronic Material and Component Symposium
Washington, D. C.
May 1–3, 1956
(*Final date for submitting papers—February 1*)

North Eastern District Meeting
Rochester, N. Y.
May 2–4, 1956
(*Final date for *TP—Feb. 1, ‡DP Syn.—Feb. 15 DPMs—March 2*)

*TP—Transactions paper
†CP SYN.—Conference Synopsis
CP MS—Conference Manuscript
(The CP Syn. date is 15 days before the CP Ms date)
‡DP SYN.—District Synopsis
DP MS—District Manuscript (the DP Syn. date 15 days before the DP Ms date)

VIEW OF A SECTION of the business district of Rochester, N. Y., showing new highway, War Memorial Building, and Library Building on the Genessee River.

Varied Program Planned for AIEE North Eastern District Meeting

THE NORTH EASTERN District Meeting will be held in Rochester, N. Y., May 2–4, with headquarters established at the Sheraton Hotel on East Avenue. A full and varied technical program is being arranged for five sessions. The meeting will open with a general session addressed by a prominent Rochester engineer. A total of 13 technical sessions will be on the program covering such diversified subjects as communication, transistors and semiconductors, illumination, transformers, insulators and insulation, instrumentation, industrial electronics, and others.

Social events will include a smorgasbord and a dinner-dance. The smorgasbord will be held on Wednesday evening, May 2, with all registered members having a chance to attend the American Bowling Congress Tournament, which will be in session at that time. The dinner-dance will be the highlight of activities on Thursday, May 3.

Four inspection trips are being arranged, including one through the Kodak Park Works of the Eastman Kodak Company, The Russell Station of the Rochester Gas and Electric Corporation, the Eastman House, the Photographic Museum, and the Lapp Insulator Company.

The Ladies Committee is arranging a varied program of activities for the women who attend. Activities will include a luncheon and bridge at the Monroe Golf Club, a trip through the Eastman House and, if possible, a trip through the Rochester Institute of Technology's craft school.

The Student Activities are being arranged by the local chairman, co-operating with the Student Co-ordinator of the District.

Blocks of rooms have been set aside at the Sheraton Hotel for members and guests. Further information about the various rates and the method of making reservations will be forwarded to all North Eastern District members in the near future.

The members of the North Eastern District Meeting General Committee are: C. G. Plomasen, general chairman; J. A. Gienger, vice-chairman; J. D. Hershey, advisory; H. A. Brown, chairman, Rochester Section; E. M. Morecock, meetings and papers; R. H. Rankin, reservations; C. E. Tuites, Student meeting; R. A. Whitford, finance; Mrs. R. A. Whitford, women's arrangements; F. Drake, publicity; G. F. Gleason, inspection trip and transportation; J. T. Johnson, treasurer and budget; R. W. McCarty, dinner-dance; J. A. Scott, smorgasbord and ABC bowling party.

Conference on Magnetic Amplifiers To Be Held in Syracuse

A special Technical Conference on Magnetic Amplifiers, cosponsored by the AIEE Committee on Magnetic Amplifiers, the Institute of Radio Engineers Professional Group on Industrial Electronics, and the Instrument Society of America, Central New York Section, will be held in Syracuse, N. Y. at the Syracuse Hotel on April 5–6, 1956. Technical sessions, a manufacturer's exhibit of magnetic amplifiers, components, and associated products, and a banquet on Thursday evening, April 5, are planned.

The first technical session will be tutorial in nature and will consist of four papers by invited speakers who are well-known authorities in their respective fields. Papers and speakers for this session are as follows: "A General Introduction to the Theory of Magnetic Amplifiers," W. C. Johnson,

Princeton University; "Recent Advances in the Theory of Magnetic Amplifiers," R. Barker, Yale University; "Fundamentals of the Magnetization Process," Charles Bean, General Electric Company; and "Present Methods of Core Evaluation, Matching and Grading," R. W. Roberts, Westinghouse Electric Corporation.

The remaining three technical sessions will each consist of 4 or 5 papers chosen from those submitted to the Technical Program Committee and will cover the subjects of materials, components, theory, and application.

Committee chairmen for the conference are as follows: Steering Committee, H. W. Lord and A. B. Haines; Technical Program, P. L. Schmidt; Publications, David Feldman; Hotel Arrangements, John Becker; Registration, August Haedecke; Finance, J. W. Munnis; Publicity, F. J. Lingel; Co-ordination, C. F. Spitzer; and exhibits, Samuel Seely.

The registration fee for the conference will be $3 and the cost of the banquet Thursday evening will be $5 per plate. Papers presented at the conference will be published subsequent to the conference in the Report of the Special Technical Conference and will be available at $4 each, if ordered in advance at the conference. Exhibit space can be obtained at a cost of $2.50 per square foot. The usual booth size is 6- by 8-feet or 6- by 10-feet. This charge includes the booth, background curtains, a table, and chairs. Manufacturers desiring exhibit space are invited to contact S. Seely, Department of Electrical Engineering, Syracuse University, Syracuse, N. Y.

Conference Paper Open for Discussion

Conference paper listed below has been accepted for AIEE *Transactions* and is now open for written discussion until *March 2*. Duplicate double-spaced typewritten copies of the discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before *March 2*.

55-742 The Wisconsin Integrally Synchronized Computer—A University Research Project. *J. L. Armuth, C. H. Davidson, J. B. Miller, D. S. Noble, A. K. Scidmore*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 38, N. Y.

ESPS 30th Anniversary in San Francisco, California

The AIEE joins with other co-operating engineer organizations which sponsor Engineering Societies Personnel Service (ESPS) in extending to the San Francisco Office-ESPS, Calif., congratulations and best wishes for continued success on the completion of the first 30 years of service to engineers of the western states. Of the 8,000 western engineering positions filled with the assistance of the ESPS in San Francisco, 2,000 have been for electrical engineers in manufacturing, design, and installation for the electrical, electronic, and other fields. Members of the AIEE San Francisco Section who have served on the local Advisory Committee include: F. R. George, W. C. Smith, D. I. Cone, and presently H. G. Keesling, utilities co-ordinator, California Office of Civil Defense. N. S. Hibshman, secretary AIEE, and R. S. Gardner serve on the National Board of Directors for ESPS.

Fort Wayne Section To Be District Meeting Hosts

The Fort Wayne Section of the Great Lakes District will be host to the District meeting which will be held at Fort Wayne, Ind., April 16–18, 1956. The topics to be discussed are small motors, electronics, magnet wire, electric power generation, stationary electric equipment, and education. The theme of this meeting will be "Engineering Future Unlimited." All of the topics will be broken down into the two following categories: Fundamental Design and Research, and Application Development.

For further details regarding this meeting contact the publicity chairman, H. C. Kaeding, 2824 Genesee Ave., Fort Wayne, Ind.

Iowa-Illinois Section Visits Appliance Control Plant

At a recent meeting for the newly formed Iowa-Illinois Section of the AIEE, 57 members attended a dinner and inspection trip of the General Electric Appliance Control factory at Morrison, Ill. In an address after the dinner in the plant cafeteria, F. H. Holt, general manager, Appliance Control Division, General Electric Company, Morrison, Ill., emphasized the tremendous future for the appliance industry by pointing out that in 1930 only 19 types of electrical appliances were on the market, whereas in 1953 there were 54 types. The 428 million household appliances to be built in the next 5 years will boost the average yearly power consumption from 2,500 kw hours per consumer at present to 5,000 by 1960.

This trip, to the northern part of the Iowa-Illinois Section area, was a part of this Section's continuing program of developing interest and participation in the AIEE throughout its territory. The Iowa-Illinois Section, with headquarters in Rock Island and Moline, Ill., and Davenport, Iowa, was organized as a full Section in September 1954, to cover 11 eastern Iowa counties and 5 western Illinois counties in the Mississippi Valley region between Dubuque and Keokuk, Iowa.

Award for Science Fair Presented by Arizona Section

At a recent general meeting of the Arizona Section at the Westward Ho Hotel, an award was presented to the Arizona Science Teacher's Association for their sponsorship of the Arizona Science Fair held last April. The award consisted of a Certificate of Commendation and a check for $25 in recognition

AN INSPECTION STATION in the range oven timer production line at the Appliance Control Plant of the General Electric Company, Morrison, Ill. Shown are some of the 57 members of the AIEE Iowa-Illinois Section who attended the dinner meeting and inspection tour of the plant. F. H. Holt, left, general manager, appliance control department, is shown describing the operations at this station.

CHAIRMAN of AIEE Arizona Section, R. H. Hartley, left, presents E. M. Gurr, Arizona Science Teachers Association president, with award and check for excellence of the Arizona Science Fair.

Courtesy of Arizona Republic

of their service to science and engineering. It was presented by Americo Lazzari, Arizona Public Service Company, to Alan Wager, director of the Arizona Science Fair. The Fair is designed to recognize outstanding students in science and engineering, and to stimulate interest in these fields.

Serving on the Committee of Awards were: C. A. Poppino, General Electric Company, chairman; Americo Lazzari, Arizona Public Service Company; and W. G. Scott, Salt River Power District.

The principal speaker of the meeting was H. A. Leggett, vice-president of the Valley National Bank, who discussed the Industrial Growth of Arizona.

Memphis Section Presents Award for Outstanding Services

J. R. Stevenson, retired director of the Electric Division of the Memphis Light, Gas and Water Division, has received the "Award for Outstanding Services to the electrical industry and to the citizens of Memphis, Tenn.," at the December meeting of the AIEE Memphis Section. The award will be given to an engineer deserving special recognition for services to the engineering profession as determined by an AIEE Board of Directors.

Mr. Stevenson received a bachelor of science degree in electrical engineering from the University of Illinois, and was elected to the national honor fraternities Tau Beta Pi and Eta Kappa Nu. He was elected a member of the national mathematics fraternity, Pi Mu Epsilon, at Washington University. He has served as manager of the Monmouth

WINNER of the Award for Outstanding Services, J. R. Stevenson, former director of the Electric Division of the Memphis Light, Gas and Water Division, after receiving the award from C. Young, Chairman of the AIEE Memphis Section, during the December Meeting. In the background is the new AIEE Memphis banner; similar banners have been distributed to all AIEE Sections.

Public Service Company, general superintendent of the Kewanee Public Service Company, chief engineer of the Kentucky Power Company, and superintendent of production for the Community Power and Light Company. He joined the Memphis Light and Water Division in 1937. He is a member and former director of the Engineers' Club of Memphis. He is a Fellow of the AIEE and is a past director of the Memphis Section.

New York Section Honors AIEE Fellows

RECENT FELLOWS honored by the AIEE New York Section: C. F. Savage, Consultant, professional relations, General Electric Company, N. Y., for his contributions to the design and development of electrical instrumentation; A. R. Nelson, general superintendent of distribution, electric department Public Service Electric and Gas Company, Newark, N. J., in recognition of his engineering and administrative achievement in the over-all guidance of the continued development and expansion of one of the nation's largest transmission and distribution systems; W. B. Fisk, system engineer, Consolidated Edison Company of New York, Inc. for contributions to the design, installation, and operation of inside and outside plants in a large metropolitan electric system; Harry Barker, partner of Barker and Wheeler, New York, N. Y., for over half a century of active service to the electrical engineering profession as editor, educator, and consultant; C. E. Scholz, vice-president and chief engineer, American Cable and Radio Corporation, MacKay Radio and Telegraph Company, Inc., All America Cables and Radio, Inc., and The Commercial Cable Company, N. Y., for his design of high-power radio transmission systems and for contributions to international radio telegraph operations; C. E. Dean, director of publications, Hazeltine Electronics Corporation, Little Neck, N. Y. for contributions to literature in the field of communications, particularly television. Also honored but not shown in the group was Fulton Cutting, professor of physics and assistant to the president, Stevens Institute of Technology, Hoboken, N. J., for services to electronic engineering in the fields of research, management and education.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Division

Committee on Industrial Power Rectifiers (J. B. Pitman, *Chairman;* J. K. Dillard, *Vice-Chairman;* C. A. Langlois, *Secretary*). The Working Group on Revisions of ASA Standards has completely reviewed the ASA Standards for Pool Cathode Mercury-Arc Power Converters (C34.1-1949, formerly AIEE Report No. 6), proposing revisions due to advances in the art and to conform with the International Electrotechnical Commission standards.

The Subcommittee on Mechanical Rectifiers has outlined plans for standards for mechanical rectifiers, beginning with terminology, definitions, nomenclature, and symbols.

Science and Electronics Division

Committee on Dielectrics (L. J. Berberich, *Chairman;* K. N. Mathes, *Vice-Chairman;* E. L. Brancato, *Secretary*). The Committee on Dielectrics has been extremely active since its inception August 1, 1955. It succeeds the former Subcommittee on Dielectrics of the Basic Sciences Committee. It has five Subcommittees, namely: Subcommittees on Gaseous Dielectrics, Solid Dielectrics, Liquid Dielectrics, Corona and Radiation Effects on Dielectrics, and Thermal Evaluation of Insulating Materials. The organization of a West Coast Subcommittee is contemplated. The function of this Subcommittee would be to represent the main Committee and to sponsor insulation sessions at meetings of the Institute in the West Coast area.

With the increasing importance of nuclear activities, it is contemplated to separate the Radiation Effects activity from the Subcommittee on Corona and Radiation Effects on Dielectrics and form a separate Subcommittee on Radiation Effects on Dielectrics.

While all of the Subcommittees have been engaged in sponsoring papers and sessions at Institute meetings, the Subcommittee on Thermal Evaluation of Insulating Materials has also undertaken a special activity. This involves the development of a series of test procedures for the thermal evaluation of insulating materials. The first of these, entitled "Proposed Test Procedure for Evaluation of the Thermal Stability of Enamelled Wire," was issued in October 1955 as AIEE Publication No. 57. Other test procedures which are under development are for rectangular enamelled wire, fibrous covered magnet wire, varnishes, flexible sheet insulation, rigid sheet insulation, mica composites, and tubing and sleeving. In addition, this Subcommittee has under development a guide for the preparation of test procedures for the thermal evaluation of insulating materials which will eventually become part of AIEE Standard No. 1. This AIEE Insulation Temperature Standard is now being revised by AIEE Coordinating Committee No. 4.

Power Division

Committee on Transformers (J. R. Meador, *Chairman;* D. L. Levine, *Vice-Chairman;* J. H. Chiles, Jr., *Secretary*). At the Committee meeting in New York on October 19, 1955, reports of the seven Subcommittees were presented and discussed. A substantial amount of work has been started to supply material for inclusion in the new format for ASA *C57*. Dielectric test tables for the various types of apparatus are nearing completion.

Proposed Test Codes for power factor testing of power and distribution transformers have now been issued for trial use. Impulse testing was actively discussed and a proposed impulse testing guide is in the early stages of preparation.

AIEE Section Meeting in Cleveland

PROOF that electric power is as free as sunlight was demonstrated at an AIEE Section Meeting in Cleveland. Dr. Gordon Raisbeck of the Bell Telephone Laboratories' technical staff illustrated the basic principles of the science of stretching into space, extracting electrical energy, and setting it aside for future use. Dr. Raisbeck (center) is discussing some of the problems associated with solar battery design with G. Canning (right), Cleveland Section chairman, and J. Ponstingl (left), publicity chairman of the Cleveland Section.

Great Lakes District Meeting

SOME MEMBERS of the committee that are organizing the Great Lakes District meeting on April 16–18, 1956, at Fort Wayne, Ind. From left to right they are: C. J. Herman, program chairman; R. W. Fackler, registration reservation chairman; J. Carroccio, general chairman; H. C. Koeding, publicity chairman; and D. B. Searls, inspection trips and transportation chairman.

An effort is being made to get the insulation systems concept into use to replace the insulation class material designations, particularly for dry-type transformers. A great deal of progress has been made in developing functional temperature endurance tests.

It is expected that the proposed guide for the maintenance of insulating oils will soon be ready for submission to the Standards Committee.

The two new Subcommittees on Standards and on Audible Sound have started to function. Revision of bushing testing standards is believed necessary, and a working group is being formed to review the situation and make recommendations. This matter is of particular interest in the active West Coast Subcommittee.

A proposed guide for operation and maintenance of dry-type transformers with Class B insulation (AIEE Publication No. 53, October 1952) has been revised after being in trial use, and will be submitted soon for approval.

AIEE PERSONALITIES

Vannevar Bush (F '24, HM '49), president of the Carnegie Institution of Washington, retired on January 1. He presented his final report to the Institute's Board of Trustees on December 9 in which he briefly reviewed the progress that has been made by the Institution's staff and assessed the probable contributions that fundamental science can make to a solution of some of the great problems that confront our civilization. Holder of many honorary degrees, medals and awards, and U. S. patents, Dr. Bush has held numerous positions of leadership in governmental, scientific, and research organizations and is the author of a wide range of subjects. He was chairman of the National Advisory Committee for Aeronautics from 1939 to 1941. In 1940 he was made chairman of the National Defense Research Committee, and a year later was appointed director of the Office of Scientific Research and Development. From 1942 to 1946, Dr. Bush was chairman of the Joint Committee on New Weapons and Equipment of the Joint United States Chiefs of Staff. From 1946 to 1947, he headed the Joint Research and Development Board, and from 1947 to 1948 he was chairman of the Research and Development Board of the National Military Establishment. He is a member of the Council on Foreign Relations. He is a Fellow of the American Physical Society, and an Honorary Member of the Franklin Institute. He is a member of the American Society for the Advancement of Science, National Academy of Sciences, American Society for Engineering Education, Tau Beta Pi, Kappa Eta Kappa, Phi Beta Kappa, and Eta Kappa Nu. He has served on the following AIEE committees: Electrophysics (1924–32, Chairman 1931–33); Power Transmission and Distribution (1925–29); Research (1924–30, 1939–41); Education (1928–29); Meetings and Papers, Technical Program (1929–33, 1937–38); Edison Medal (1933–38); National Research Council, Division of Engineering and Industrial Research (1935–39); Lamme Medal (1936–39, Chairman 1938–39); Co-ordination of Institute Activities (1937–38); American Association for the Advancement of Science Council (1938–40); and Board of Directors (1937–41). Dr. Bush was the Lamme Medalist for 1935; Edison Medalist, 1943; Washington Award, 1946; Hoover Medalist, 1946; and John Fritz Medalist, 1951.

M. J. Kelly (M '26, F '31), president of Bell Telephone Laboratories, has been elected a foreign member of the Swedish Royal Academy of Sciences for his research studies in electronics and electrotechnics. He is one of 108 foreign members from countries outside Sweden. The Academy, which was founded in 1739 for the encouragement of the natural sciences and mathematics, awards two of the prizes of the Nobel Foundation (chemistry and physics). It does most of its work through scientific institutions, publication of scientific pamphlets, and in providing funds to outstanding scientists and authors. Among the distinguished Americans who are members of the Academy are: Irving Langmuir, Harlow Shapley, Harold C. Urey, and E. O. Lawrence. The late Albert Einstein was also a member. Dr. Kelly also was nominated by the City of Genoa, Italy, to receive the first Christopher Columbus International Communication Prize. He received this in recognition of ". . .the planning, now being placed into practice, of the submarine telephone cable which will make it possible to establish 36 telephone circuits across the Atlantic between Scotland and Canada with extension to New York, 'intending furthermore to reward hereby the numerous scientists, research workers, and engineers who have contributed in the planning, production and placing in operation of the intercontinental submarine telephone line'". The Christopher Columbus International Communication Prize, instituted as a memorial to Christopher Columbus, is intended to honor any outstanding discovery or research work completed in the previous four years to aid communications among men. The award will be conferred each year in one of four categories of communications: maritime, air, land communications, and telecommunications. Awards will be based on recommendations of the Italian Higher Institute of Telecommunications and the Superior Research Council, and may be given to an individual, an organization or, collectively, to a group of persons. Presentation of the prize will take place each October in Genoa, on the occasion of the International Meeting of Communications. Dr. Kelly has been on the following committees of the Institute: Communications (1934–37); Standards (1934–39, 1941–43); Basic Sciences (1937–46); Lamme Medal (1940–43); Research (1940–45; 1947–50); Chairman (1949–51); Award of Institute Prizes (1949–51), Technical Program (1949–50). (See page 706, August *Electrical Engineering* 1955, for biography of Dr. Kelly.)

J. E. Hobson (AM '36, M '41, F '48), director of Stanford Research Institute (SRI) since March 1948, has submitted his resignation effective March 31, 1956. Under Dr. Hobson's leadership SRI has grown during the past 9 years to become one of the largest independent applied research organizations in the United States. He is a native of Marshall, Ind. He graduated with distinction from Purdue University and took his doctor's degree, magna cum laude, from California Institute of Technology. Immediately prior to his appointment to head SRI, he was director of the Armour Research Foundation for four years. He has been an instructor in mathematics at Earlham College, an instructor in electrical engineering at Armour Institute of Technology, central station engineer for Westinghouse Electric Corporation, and director of the department of electrical engineering, Illinois Institute of Technology. Eta Kappa Nu, honorary society of electrical engineers, named Dr. Hobson "Outstanding Young Electrical Engineer of the United States in 1940." The society further honored him by electing him to its presidency for its golden anniversary year, 1953–54. He was consultant to the Manhattan District of the Army Engineers, and was chairman of the Mexican-American Conference on Industrial Research. Under the auspices of the Mutual Security Agency he participated in a series of industrial research activities in Germany, Austria, and Italy during the year 1951–52. He has been board chairman of the National Electronics Conference, member of the Division of Engineering and Research and the Building Research Advisory Board of the National Research Council, the National Security Industrial Association's Ordnance Advisory Committee, and of the American Industrial Development Council. He recently was named a Fellow of the Institute of Radio Engineers in recognition of his contribution to, and leadership in, electronic research. Dr. Hobson has been active with the AIEE and has served on the following committees: Basic Sciences (1941–45), Electrochemistry and Electrometallurgy (1943–45), Education (1944–45), Power Transmission and Distribution (1944–47), Standards (1945–50), Communication (1946–47), Registration of Engineers (1946–49, Chairman 1947–51), Chemical, Electrochemical, and Electrothermal Applications (1946–53), Research (1947–49, 1954–55, Chairman 1955–56), Electronics (1947–56), Co-ordinating Profesional Group (1947–49), National Bureau of Engineering Registration, Advisory Board (1947–49), Instruments and Measurements (1949–55), Liaison Representative on Standards (1952–55), Science and Electronics Division (1953–56), and Technical Operations (1955–56). **A. M. Zarem** (AM '43, F '50), has resigned his positions as assistant director and manager of the Southern California Division of SRI to enter the field of private consulting in Los Angeles, Calif. He will be engaged in independent research counseling and advisory services to business and industrial management. He will specialize in reviewing research policy programs and planning with a view toward improving utilization of industrial resources to match the demand of changing technology. Dr. Zarem has long been identified with professional circles in electronics and physical sciences research on the West Coast since joining SRI in 1948. He is a graduate of Illinois Institute of Technology and has a master of science and a

doctor's degree from the California Institute of Technology. A member of numerous professional societies, he was chosen the nation's outstanding young electrical engineer by Eta Kappa Nu, electrical engineering honor society, for the year 1948. In 1950 he was named one of "America's Ten Outstanding Young Men" by the U. S. Junior Chamber of Commerce, a selection made for both civic and professional achievements. He has served on the AIEE committees on Electronics (1948–55, Chairman 1955–56), Electrical Techniques in Medicine and Biology (1951–56), and Science and Electronics Division (1955–56).

W. J. Barrett (M '36, F '50), electrical coordination engineer, Bell Telephone Company, Newark, N. J., was elected president of The United Engineering Trustees, Inc. (UET). Mr. Barrett is a director of the Engineers Joint Council. He is well known in engineering circles, being treasurer and a director of the AIEE, which he represents on the board of UET. The UET was incorporated in 1904 for the chartered purpose of the advancement of the engineering arts and sciences in all their branches and to maintain a free public engineering library. It acts in a fiduciary capacity for a large number of joint activities of the major engineering societies. Mr. Barrett has served the AIEE as director (1949–52) and as Treasurer (1953–56). He has served on the following AIEE Committees: Sections (1948–50); Finance (1949–51, Chairman 1950–52); Board of Directors (1949–55); Communication Division (1950–53); Lamme Medal (1950–53); Planning and Co-ordination (1950–56); Headquarters (1950–53); Executive (1950–55); Joint AIEE-IRE Co-ordination Committee (1951–53, Chairman 1953–55); Board of Trustees, the United Engineering Trustees, Inc. (1951–56); Board of Examiners (1952–53); and Engineers Joint Council Representative (1954–56).

C. F. Dalziel (AM '33, M '39), professor of engineering, University of California, Berkeley, has been appointed by the International Labour Office in Geneva, Switzerland, as a member of the Committee on Occupational Safety and Health for a term of 3 years. The committee on which he will serve is an advisory group of experts in the field of occupational safety and health. Professor Dalziel is noted for his research on the effects of electric shock on humans and animals.

E. A. Walker (AM '34, F '47), dean of the College of Engineering and Architecture at the Pennsylvania State University, has been named vice-president of the university, effective June 30, 1956. Dr. Walker will coordinate and stimulate the research program, and will have general supervision over operational activities. Dr. Walker was born in Long Eaton, England, and received a bachelor, master, and doctor of science degree from Harvard University. During the years 1942 to 1945, he served as research associate, assistant director, and finally associate director of the Harvard Underwater Sound Laboratory at Cambridge, Mass., where he had charge of the development of ordnance weapons. For his work there, he was awarded the Naval Ordnance Development Award and also a Presidential Certificate of Merit. He has served as a vice-president of the American Society for Engineering Education, and as a director of the Engineering College Research Council. He is a member of Tau Beta Pi, the American Physical Society, and a Fellow of the Acoustical Society of America. He has served on the following AIEE committees: Membership (1942–43), Education (1945–46), Research (1947–51), and Charles LeGeyt Fortescue Fellowship (1952–55, Chairman 1954–55).

Charles Weyl (AM '20, M '47), president International Resistance Company (IRC), Philadelphia, Pa., has been awarded a Centennial Citation by the University of Pennsylvania. Voted by the faculty as a recipient of this award for professional achievements, contributions to the public welfare, and services to the university, he was cited "... for stimulating advocacy of the humanities in the engineering curriculum, for pioneering work in radiologic physics, and for responsible administration in the graphic arts and electrical manufacturing industries." Following graduation from Pennsylvania University, Mr. Weyl joined the Bell Telephone Company as an apprentice electrical engineer. He became an instructor in electrical engineering at the University of Pennsylvania and 5 years later became assistant professor. He was appointed associate professor, and later professor of electrical engineering. He joined the IRC organization as assistant to the president in 1944, and was elected executive vice-president a year later. He had been a director of IRC for 24 years when he was elected to the presidency. He is also currently chairman of the Board of Directors of Edward Stern and Company, Inc., Philadelphia, Pa. He is the author of "Apparatus and Technique for Roentgenography of the Chest," coauthor of "Radiologic Physics," and author of numerous professional articles. Among other awards presented to Mr. Weyl was the Franklin Institute Longstreth Medal in 1930. **Jesse Marsten** (AM '26, M '50), vice-president of affiliates and engineering, was elected senior vice-president by the company's Board of Directors. Mr. Marsten has been actively engaged in IRC expansion for the past 25 years. He joined the company as chief engineer, and was elected to vice-president of affiliates and engineering. He is a member of the IRC Board of Directors and Executive Committee, and of IRC subsidiaries—Circuit Instruments Inc., Hycor Companies, Ircal Industries, and Emec, Inc. He has been consultant to the Research Development Board of the Defense Department, and still acts as consultant to their Electronics Group. He is a member of the Institute of Radio Engineers. Mr. Marsten is also active in Radio-Electronics-Television Manufacturers Association engineering affairs. He has served on the AIEE committee on Electronics (1955–56).

F. M. Tait (AM '94, F '12), founder and chairman of the Board of Directors, Dayton Pump and Manufacturing Company, Dayton, Ohio, has formed the Frank M. Tait Foundation in Dayton, Ohio, for charitable, scientific, educational, and religious purposes. The foundation will be administered by a Board of Trustees comprised of Dayton residents. The trustees will have the right to determine investments and distribution of the Foundation's capital. Mr. Tait is known as a pioneer in the United States public utilities industry. His utility career started in his home town. This led him into executive direction of utilities in seven states and Japan, with his foremost interest being centered throughout his career in the Dayton Company which he took over in 1905. He founded the Dayton Pump Company in 1908. At one time he was active in the executive direction of 35 corporations. Currently, in addition to his Dayton Pump connection, he is chairman of the board and a member of the executive committee of the Dayton Power and Light Company, and a director and member of the executive committee of the United States Pipe and Foundry Company, Birmingham, Ala.; and has financial interests in many other corporations in the United States. He is past president of the Edison Pioneers, vice-president and trustee of the Thomas Alva Edison Foundation, past president of the Ohio Electric Light Association and the National Electric Light Association which now is the Edison Electric Association, and a member of the American Gas Institute. He holds honorary doctorates from Lehigh University and the University of Dayton.

R. C. Sprague (M '40, F '49), chairman of the board of the Sprague Electric Company, North Adams, Mass., has received the Silver Knight of Management Award of the National Association of Foremen (NAF). Mr. Sprague received this award for the practice of the NAF code of ethics in his everyday business, for his loyalty to objectives of the NAF, and his efforts for the advancement of the American free enterprise system. He is a past president of the Radio-Electronic-Television Manufacturers' Association and at present is consultant to the National Security Council.

H. D. Beebe (M '44), head of the electric department, Stone and Webster Service Corporation, New York, N. Y., has been elected a vice-president of the firm. Mr. Beebe has been with the corporation since 1950. He formerly was general superintendent with the Tampa Electric Company, Fla.

R. G. Schimpf (M '50), specialist in automatic and semiautomatic machinery for the Elgin National Watch Company, Ill., was named engineering manager of the company's ordnance research and engineering department. Mr. Schimpf will supervise classified ordnance research in missile components and other Government projects. He has been a member of the company's Industrial Products Engineering Division since 1950. He is a member of the Institute of Radio Engineers.

F. J. Roehm (AM '41, M '46) manager of engineering services for the International Business Machines Corporation (IBM) Endi-

cott Laboratory, N. Y., has been appointed to the staff of the Director of Engineering, World Headquarters. He was also appointed electric accounting machines product engineer for IBM. Mr. Roehm was employed by IBM in 1948 as a design engineer and two years later was assigned to mobilization planning study for Air Force computer equipment production. In 1951 he was named project engineer at the Laboratory. After two years, he was appointed assistant engineer to the production engineer to assist in technical and administrative functions, and to co-ordinate electronic projects and special assignments. He obtained the degree of bachelor of electrical engineering from Syracuse University in 1940. He holds membership in the Institute of Radio Engineers. **K. E. White** (AM '44, M '53), project engineer and manager of the electrical laboratory of IBM, Endicott, N. Y., was appointed manager of the company's engineering services. Mr. White graduated from the University of New Hampshire with a bachelor of science degree in electrical engineering in 1935. He has served on the AIEE Committee on Communication Switching Systems (1952–56).

M. F. Behar (AM '37), vice-president and editor, Instruments Publishing Company, Pittsburgh, Pa., was made an honorary member of the Instrument Society of America (ISA) during the Society's 1955 Tenth Annual Instrument-Automation Conference and Exhibit in Los Angeles, Calif. The award was presented to Major Behar for his contributions to industry in pioneering the basic literature and terminology for the application of instruments in measurement and the control of automation in industrial production methods. He received his education in France, Switzerland, and England, and in the United States at Pratt Institute, Brooklyn, N. Y. and Columbia University, New York, N. Y. He served in World War I in the United States Army Infantry and Ordnance Corps. In 1929, he became editor of *Instruments* magazine, the first national publication devoted to instrumentation and automation in industry.

S. F. Moore, Jr. (AM '53), project engineer, General Electric Company, Utica, N. Y., and **M. T. Reese** (AM '55), production engineer for the company in the voltage regulator department at Pittsfield, Mass., have been transferred to the staff of the company's new D-C Electrolytic Capacitor Plant at Irmo, S. C. Mr. Moore, who will serve as a design engineer, has done outstanding work as a project engineer designing radar equipment since he joined the company in 1953. He graduated from the University of South Carolina in 1950 with a bachelor of science degree in electrical engineering. While in school, he was Chairman of the Student Branches of the AIEE and the Institute of Radio Engineers, and is still a member of both organizations. Mr. Reese joined the company in 1947 as an engineer in the test program. In 1948, he did feeder regulator control design work. He holds a patent on an electronic motor speed reduction device. **F. G. Stebbins** (M '44), power capacitor sales manager for the company in Pittsfield, Mass., has been appointed manager of marketing administration for the capacitor department at Hudson Falls, N. Y. Mr. Stebbins is a veteran of 37 years' service with the company and has played a leading role in the growth of the capacitor department. He graduated from Union College in 1918 with a bachelor of science degree in electrical engineering and joined the company's engineering test program that year. Later assignments included International General Electric, the Central Station Group, and the transformer department (now the Transformer and Allied Products Division), where he became assistant sales manager for distribution transformers. **W. G. Hart** (AM '45), supervisor in power capacitor sales for the company in Los Angeles, Calif., has been appointed manager of power capacitor sales at Hudson Falls, N. Y. Mr. Hart graduated from the University of California in 1942. He joined the General Electric's engineering test program in 1943, and was given a 3-year assignment with the Manhattan Engineering District Atom Bomb Project. He served first at the University of California's Radiation Laboratory and later at the company's general engineering laboratory at Schenectady, N. Y. He received the Manhattan District Special Award for his contribution to the development of the atomic bomb. In 1946, he transferred to the sales organization, and from 1948 to 1955 was district transformer specialist in the apparatus sales office in Los Angeles. Mr. Hart is a member of the Electric Club of Los Angeles, and the Pacific Coast Electrical Association. **W. C. Dunlap, Jr.** (M '55), physicist in the companys Electronics Division, Syracuse, N. Y., has been named a consultant in the semiconductor field in the electronics laboratory. He has been engaged in the field of semiconductors since 1945. He worked in most of the major areas of interest in the development of transistors, rectifiers, Hall effect and magneto-resistive devices, photocells, thermistors, and infrared detectors. He graduated from the University of New Mexico with a bachelor of science degree in physics and chemistry in 1938. He received a doctor's degree in physics at the University of California, Berkeley, in 1943. He has served on the AIEE Basic Sciences Committee (1951–56).

OBITUARIES

John Davidson, Jr. (AM '19, M '21), telephone engineer, Federal Telephone and Radio Corporation, Clifton, N. J., died recently. He was born in New Orleans, La., in 1885. He received a bachelor of engineering degree from Tulane University in 1906 and a degree in electrical engineering in 1909 from Cornell University. In 1909 he joined the Ohio Works of the Carnegie Steel Company as a supervisor in the electrical department. Two years later he became affiliated with the American Telephone and Telegraph Company in the equipment branch of the engineering department. He did work on the equipment features involved in the application of carrier telephone methods in the telephone plant, and worked on a study of new methods of signalling in telephone toll practice while led to the development of a number of useful methods. After 39 years of service with the Bell System he retired, but 9 months later entered the field of telephone communications with the Federal Telephone and Radio Corporation. Mr. Davidson was a member of the Montclair Society of Engineers. He served as secretary for the AIEE committee on Communications for 6 years.

Laurence C. Hawkes (AM '49), application engineer of the I-T-E Circuit Breaker Company, Philadelphia, Pa., was stricken with polio and died in November. He was born in Duluth, Minn., in 1924. He received a bachelor of science degree in electrical engineering from the University of Washington, Seattle, in 1945. In 1946 he joined the H. L. Yoh Company, Inc. as a research technician. He was supervisor of a group of 20 engineers engaged in the analysis of electrical control equipment furnished to the Bureau of Ships. In 1948 he joined the I-T-E Circuit Breaker Company as an application engineer in switchgear sales. Mr. Hawkes was chairman of the Membership Committee, Boston Section.

Fernand Émile d'Humy (AM '20, F '30, Member for Life), retired vice-president of the Western Union Telegraph Company, died December 22. He was born in London, England, in 1873. In 1888 he came to the United States and attended the Massachusetts Institute of Technology. He entered the communications field with the Postal Telegraph Company in 1891. He joined the Western Union Telegraph Company as central office engineer 19 years later and was responsible for the design of all United States equipment and office buildings used in the company's service. In World War II he was liaison officer between the National Defense Research Committee and Western Union, directing the development and production of numerous items in communications for the armed forces. In 1934 he was appointed vice-president of engineering for Western Union. In 1946 he was made vice-president in charge of development and research activities of the company, a position he held until his retirement in 1949. He is the inventor of a wide variety of engineering developments and holds many patents for his processes. His professional associations included membership in the Institute of Radio Engineers (London), the Society of American Military Engineers, the American Geophysical Union, and the National Aeronautical Association.

Horace P. Liversidge (AM '12, F '43), chairman of the board of the Philadelphia Electric Company, Pa., died suddenly in December. He was born in Norristown, Pa., in 1878. He received his technical education from Drexel Institute of Technology. His work in the utility industry started in 1898 when he was employed as a wiring inspector by the Edison Electric Light Company, forerunner of Philadelphia Electric. It was not more than a year after his employment with the Edison Electric Light Company that he began his rise through numerous supervisory posts. He was elected vice-president in 1924, vice-president and general manager in 1926, a director in 1936, president in 1938, and

chairman of the board in 1947. Mr. Liversidge was especially active in promoting co-operation among the various branches of the electrical industry. From the earliest days of his executive activity, he was an exponent of interrelated effort in the industrial field. His work in this direction received national recognition in 1932, when he received the James H. McGraw Award "... in recognition of his distinguished contribution to the advancement of co-operation in the electrical industry." He received other awards for distinguished contributions to the welfare of his community and country. He received the honorary degree of doctor of engineering in 1940 from the Stevens Institute of Technology, and the degree of doctor of science in commerce in 1943 from the Drexel Institute of Technology. He was active with many industry groups, including the advisory committee of the Edison Electric Institute; the board of governors of the Electrical Association of Philadelphia, of which he was a past president; the board of trustees of the Thomas Alva Edison Foundation, Inc.; the Association of Edison Illuminating Companies, of which he was a past president; The American Society of Mechanical Engineers; the Illuminating Engineering Society; and the awards committee of the James H. McGraw Award for Electrical Men. He served on the following AIEE committees: Meetings and Papers (1920–21); Power Stations (1918–24, Chairman 1920–21); Electrical Machinery (1923–24); Edison Medal (1927–29); and Code of Principles of Professional Conduct (1928-29).

Robert E. Shelby (AM '36, F '51), vice-president and chief engineer of the National Broadcasting Company (NBC), died in December. He was born in Austin, Tex., in 1906. He attended Texas University and in 1927 received a bachelor of science degree in electrical engineering, a bachelor of arts degree in 1928, and a master's degree in 1929. He joined NBC in 1929 and was a pioneer in the development of black and white and color television, being credited with many technical advancements in the industry. He was placed in charge of the first NBC television laboratory in the Empire State Building, New York N. Y., in 1931. From 1935 to 1937 he assisted in the Radio Corporation of America (RCA)-NBC field tests of electronic televison. He was director of color television at NBC and played an important part in RCA's compatible color television research. In 1954 he was promoted to vice-president and chief engineer for NBC. During World War II he directed NBC research and served as a consultant to the National Defense Research Committee. He was a Fellow of the Institute of Radio Engineers and a member of the Society of Motion Picture and Television Engineers. He served on the AIEE committees on Communications (1946–49) and Television and Aural Braadcasting Systems (1949–56).

Samuel Dewey Summers (AM '37, M '46), retired consultant of the Navy Research Laboratory, died recently. He was a native of Hornbeak, Tenn., and was born in 1898. He attended Memphis State College and received a bachelor of science degree in electrical engineering from Tri-State College, Angola, Ind., in 1923. He did graduate work at the Massachusetts Institute of Technology and the University of Michigan, and received a master of science degree in electrical engineering from the University of Maryland. He served as an instructor of electrical engineering at Tri-State College in 1923–24. Later, from 1931 through 1943, he became a professor in this subject. For 3 years of this period he was head of the electrical engineering department. From 1925 through 1931, he was employed as an electrical engineer with the Commonwealth and Southern Corporation at Jackson, Mich., where he did electrical design work. During World War II, he served as an electronics officer in the U.S. Navy and was assigned to the Naval Research Laboratory as a member of the Aviation Electronics Service Unit. He Joined the Naval Research Laboratory as a consultant on problems relating to naval electrical and electronic applications in 1945, and served in that capacity until his retirement in 1955. Mr. Summers was a member of the Institute of Radio Engineers. He served on the following AIEE committees: Air Transportation (1947–54, Chairman 1947–49); General Applications Division (1947–55); Standards (1946–49); Technical Program (1946–49); Award of Institute Prizes (1950–52); Safety (1951–54); and Liaison representative of Standards Committee (1953–54).

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of December 15, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Alke, R. J., electric service supervisor, Westinghouse Electric Corp., Kansas City, Mo.
Bettersworth, T. A., supervising electrical engineer, Pacific Gas & Electric Co., San Francisco, Calif.
Bohrer, L. E., assistant professor of electrical engg., Lamar State College of Technology, Beaumont, Tex.
Boyd, J. G., asst. supervisor of transmission, Southwestern Gas & Electric Co., Shreveport, La.
Briney, G. S., section head, Brown Instrument Div., Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.
Burleson, A. J., Jr., relay specialist, Westinghouse Electric Corp., Newark, N. J.
Byrd, J. D., Jr., ordnance engineer, U. S. Naval Ordnance Laboratory, Silver Spring, Md.
Cline, G. W., electrical engineer, Brown, Raymond & Walsh, APO 285, New York, N. Y.
Cupples, J. J., application engineer, Butler & Land Co., Dallas, Tex.
Elmstrom, R. E., supervising electrical engineer, Alaska District, U. S. Corps of Army Engineers, Seattle, Wash.
Erickson, D. H., engineer, American Tel. & Tel. Co., New York, N. Y.
Finman, B., engineer, The Southern New England Tel. Co., New Haven, Conn.
Fox, J. W., manager, applied engineering, Clark Controller Co., Cleveland, Ohio
Freeman, H., engineering section head, Sperry Gyroscope Co., Great Neck, N. Y.
Freeman, J. R., defense labs. staff, Lincoln Lab., Massachusetts Institute of Technology, Lexington, Mass.
Gilcrest, G. B., application engineer, General Electric Co., San Francisco, Calif.
Gipe, A. B., electrical engineer, Whitman, Requardt & Associates, Baltimore, Md.
Greer, J. H., engineer, General Electric Co., Richland, Wash.
Groth, W. B., member of technical staff, Bell Telephone Labs., New York, N. Y.
Grund, J. B., senior engineer, Sylvania Electric Products, Inc., Emporium, Pa.
Hess, R. G., chief electrical engineer, John Graham & Co., Seattle, Wash.
Holden, P. B., field engineer, Line Material Co., Seattle, Wash.
Huckins, G. J., supervising electrical service engineer, Westinghouse Electric Corp., Beaumont, Tex.
Huntemer, R. J., electrical engineer, Goodyear Atomic Corp., Portsmouth, Ohio
Lacopo, M. J., section head, American Gas & Electric Service Corp., New York, N. Y.
Lester, J. B., manager, planning & estimating branch, U. S. Naval Air Station, Jacksonville, Fla.
Miller, R. C., assistant chief, construction div., American Gas & Electric Service Corp., New York, N. Y.
Osborne, M. J., electrical supt., Bowaters Southern Paper Corp., Calhoun, Tenn.
Pakis, Val, electrical designer, Dingle-Clark Co., Cleveland, Ohio
Purandare, D. N., technical director, The Western India Engineering Corp., Ltd., Bombay, India
Raymond, W. R., special products sales manager, The Pyle-National Co., Chicago, Ill.
Ruble, G. B., instructor of electrical engineering, Rutgers University, New Brunswick, N. J.
Ruth, J. A., patent engineer, International Business Machines Corp., New York, N. Y.
Secor, G., electrical engineer, Cutler-Hammer, Inc., Milwaukee, Wis.
Sherrard, R., Jr., specialist development engineer, General Electric Co., Schenectady, N. Y.
Shrider, K. L., electronic development engineer, Reliance Electric & Engineering Co., Cleveland, Ohio
Shulman, J. M., engineering section manager-motors, Westinghouse Electric Corp., Sunnyvale, Calif.
Smith, L. N., research electrical engineer, New Jersey Woodfinishing Co., Woodbridge, N. J.
Smith, S. L., electromechanical research engineer, North American Aviation, Inc., Downey, Calif.
Spence, D. W., assistant professor & supervisor, electrical engineering dept., Syracuse University, Syracuse, N. Y.
Stevenson, W. A. S., transformer superintendent, Arizona Public Service Co., Phoenix, Ariz.
Troxel, S. H., Jr., supervisor of statistics, The Ohio Bell Tel. Co., Cleveland, Ohio
Vogt, S. H., head, auxiliary power unit, U. S. Bureau of Aeronautics, Washington, D. C.
Weller, R. L., physicist, Brookhaven National Lab., Upton, N. Y.
Westrom, A. C., chief engineer, Hubbard & Co., Chicago, Ill.
Wilde, N., staff member, Sandia Corp., Albuquerque, N. Mex.
Willoughby, F. R., service assistant, Westinghouse Electric Corp., Huntington, W. Va.

47 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before February 25, 1956, or March 25, 1956, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Allen, L. B., Allen & Hoshall, Memphis, Tenn.
Baker, R. A., Public Service Electric & Gas Co., Newark, N. J.
Binder, G. P., Ebasco International Corp., New York, N. Y.
Bradbury, L. J., Plymouth County Electric Co., Plymouth, Mass.
Briggs, R. E., Robert E. Briggs, Consulting Electrical Engineer, Jackson, Miss.
Buster, E. B., S & C Electric Co., Chicago, Ill.
Calva, J. B., J. B. Calva & Co., Minneapolis, Minn.
Chiam, J. H., Dallas Power & Light Co., Dallas, Tex.
Cone, D. R., Chromatic Television Laboratories, Inc., Emeryville, Calif.
Davis, W. L., Pacific Tel. & Tel. Co., San Francisco, Calif.
Denison, J. S., A & M College of Texas, College Station, Tex.
Donaldson, W. G., Western Electric Co., New York, N. Y.
Eisenacher, P. L., General Elec. Co., West Lynn, Mass.
Fisher, W. C., Lenkurt Elec. Co., Inc., San Carlos, Calif.
Gittens, E. D., American Bosch Arma Corp., Garden City, N. Y.
Helin, C. J., Helin Engg. Co., Pasadena, Calif.
Hodgson, K. D., Bermuda Electric Light Co. Ltd., Pembroke, Bermuda
Jones, R. B., U. S. N., Fifth Naval Dist., Portsmouth, Va.
Kornfeld, R. F., Southwestern Bell Tel. Co., St. Louis, Mo.
Kratoville, F. M., James R. Kearney Corp., St. Louis, Mo.
Maurer, F. E., Olin Mathieson Chemical Corp., East Alton, Ill.
McFee, R., Bell Tel. Labs. Inc., Whippany, N. J.
Olson, R. W., Houston Technical Labs., Houston, Tex.
Saake, M. G., C. H. Ribble Co., New York, N. Y.
Saville, F. G., Mid-Essex Technical College, Chelmsford, Essex, England
Schweder, W. M., General Electric Co., Schenectady, N. Y.
Steiner, B. A. L., Ebasco International Corp., New York, N. Y.
Stern, H. H., Convair, San Diego, Calif.
Thulin, V. J., Duke Power Co., Charlotte, N. C.
Weber, K. H., General Elec. Co., Pittsfield, Mass.
Whatmough, F. R., Canadian Standards Assn., Weston, Toronto, Ont., Canada
Winter, D. F., Moloney Electric Co., St. Louis, Mo.
Young, C. L., West Texas Utilities Co., Abilene, Tex.

33 to grade of Member

OF CURRENT INTEREST

CO-OPERATION and teamwork are shown in various stages of shell molding operations. Men, upper left, pour molten metal from induction furnace. Men, foreground, *pour from ladles into shell molds.*

Metals Pilot Plant Answers New Alloys Needs

A METALS PILOT PLANT designed to bridge the gap between laboratory and commercial production of new alloys and processes has been opened by Westinghouse Electric Corporation at Blairsville, Pa. The $6 million facility under one roof includes virtually all types of metal processing equipment.

Created to be the final link in the rapidly expanding metallurgical developments the 173,000-square foot plant will help provide the new and better alloys that product design engineers are now demanding. The plant is designed to process both wrought and cast alloys with equipment flexible and large enough to permit actual manufacturing conditions. In this way, the Blairsville plant is more than a pilot plant, and its moderate production output will uncover problems that can be found only under actual manufacturing conditions.

Need for the plant became apparent several years ago when it was recognized that the key to advanced design in steam and gas turbines, generators, transformers, nuclear power reactors, etc., was the development of new metals having better temperature, strength, and magnetic characteristics. New titanium, molybdenum, expansion, and resistance alloys show particular promise.

As important as the alloys themselves is the need for practical commercial processes to manufacture these alloys into finished products. With this challenge in mind, a large portion of Blairsville is engaged in processing techniques such as forging, hot and cold rolling, heat treating, shell mold and investment casting, and powdered metallurgy.

In choosing the equipment for the new plant, flexibility and multipurpose usefulness were stressed. An example is the induction vacuum melting installation which can accommodate heats ranging from 300 to 2,000 pounds. This installation can be used for vacuum casting of large ingots as well as low-temperature vacuum annealing of titanium.

Equipment in the Blairsville plant is larger than that found in most pilot plants. This permits the manufacture of specialty metal products at competitive costs, thus allowing reasonable loading of tools that normally cannot be loaded fully on development work. This operating policy not only lowers the cost of the development work but also provides trained operating crews for all the equipment.

The plant is situated on a 540-acre tract 40 miles east of Pittsburgh and has been designed to make possible future expansion easy. But room is included within the present facilities for the manufacturing of nuclear reactor fuel elements.

Included in the plant, believed to be the largest pilot plant of its type in the country, is an 18,000-pound forge hammer and 3 smaller ones; a 1,000-ton steam-hydraulic forge press; 7 forge furnaces; 3 induction melting furnaces varying in size up to 5,000 pounds; a cold-hearth furnace; a 1,000-hp reversing, hot-rolling mill; a 500-hp reversing, cold-rolling mill; bell type and roller rail box type electric furnaces; a shot pouring facility; shell mold and lost wax investment casting facilities; arc furnaces; and other units.

Because of the electrical industry's dependence upon metals with special mechanical and electrical properties, Westinghouse has long been a pioneer in the development of special alloys. High on the list of Blairsville projects is further development of these alloys, including Discaloy, Refractaloy, K-42-B, Hipernik, Hiperco, Hipersil, and Kovar.

The first three on the list are high-temperature alloys for application in gas and steam turbines. Here, rotors and blades must withstand stresses at extremely high temperatures and also resist corrosion and remain ductile. Hipernik, Hiperco, and Hipersil are magnetic alloys used in saturable reactors, magnetic amplifiers, and choke coils.

Kovar is an expansion alloy used where an airtight seal between glass and metal is required, as in electronic tubes, glass bulb rectifiers, and x-ray tubes.

Explaining the importance of these new alloys, it was pointed out that 20 years ago steam turbines were being built to operate with steam temperatures of about 800 F and pressures of about 1,200 pounds. New units now are being designed for 1,200 degrees and up to 4,000 pounds pressure. To make these advances, new alloys were required. And to go any higher in the temperature and pressure scale will require still better alloys. That is what Blairsville hopes to provide.

Laboratories and shop areas are air conditioned where needed. Offices are ducted for future air conditioning. The plant is ventilated by high bay window vents and 36-inch roof fans.

The service facilities, such as truck docks, railroad siding, water tower, ammonia storage, etc., have all been located at one end of the building, freeing the other end of the building for possible future expansion or an additional bay back of the building.

The roof of the office and laboratory bay is so constructed as to permit the building of a second story, if needed.

Incoming power is supplied by a 15-mile long 25-kv line with air break switch and fuses feeding a single 3,750-kva three-phase 25/4.16-kv transformer. There are 10 cubicles of outdoor metal-enclosed switchgear containing metering facilities and all 4.16-kv breakers feeding underground cable to the boiler house, where the lines are carried overhead in messenger-supported armored cable. The 4.16 kv is a radial system with two feeders to the six 500-kva 480-volt power centers. The power centers feed a 480-volt plug-in bus duct network with network protectors. The other 4.16-kv feeders supply individual loads (125-hp fire pump, rolling mill motor-generator sets, high frequency in-

Above: This reversible hot rolling mill is designed to roll slabs of thicknesses up to 8 inches to a thickness of 0.090 inch. An integral roller hearth furnace reheats and holds down the temperature. Two coiler furnaces, 18 feet from the center line of the mill are designed to hold the material temperature during strip rolling. The maximum temperature is 2,000 F. *Top right:* The 18,000-pound forge hammer descends on an ingot held by an Autofloor manipulator. The hammer is designed for both open and closed die work, and can handle ingots weighing up to 6,000 pounds each. A workman is shown holding a hard steel gauge which limits hammer travel. *Bottom right:* This induction vacuum melting installation accommodates heats from 300 to 2,000 pounds. The melting installation can be used for making vacuum castings of large ingots as well as for the low temperature annealing of titanium. Roughing and final pumps lower the pressure to 10 microns.

duction furnace motor-generator set, cold hearth furnace, etc.).

A separate 8-kv line provides emergency lighting in the plant.

The office lighting is instant start fluorescent continuous units, while the shop is lighted by high bay mercury millites.

Two 15,000 pound per hour gas-fired boilers provide steam for process and heating and 150-psi steam is maintained in the high pressure line mainly for operation of forge hammers. The exhaust from the hammers is fed into the low pressure system (10 psi) and used for the heating system.

Water for the plant is supplied from 3 wells which together produce about 150 gallons a minute. Water is pumped into a 250,000-gallon water tower and a spray pond. All cooling water for the plant is pumped from the pond and returned through spray nozzles. The water tower is used for applications where clean water is required and as a standby supply in case of power failure.

Both the tower and the pond can be drawn down for shop use to only one-half capacity in order to reserve a supply for fire protection.

Two 400-cfm 100-psi rotary type compressors are also in use.

A sprinkler system protects all of the office area and about 50% of the shop area.

Ammonia from an outdoor storage tank is piped into the plant to a gas generator and the heat-treating furnace. There is also a standby hydrogen system for the heat-treating furnace.

A specially designed and segregated area provides equipment for the melting and fabrication of uranium alloys for nuclear fuel elements. Arc-casting furnaces embodying unique design innovations will be used to explore improved melting procedures for zirconium, titanium, and molybdenum alloys. Improved methods for manufacturing fuel elements are expected to lower the present high costs of this important component of the nuclear reactor.

Westinghouse feels that many of the materials essential to continued rapid growth will flow from this new facility.

Nuclear Congress and Exposition Show Peacetime Uses of Atomic Power

THE Nuclear Engineering and Science Congress, in conjunction with the International Atomic Exposition, was held December 12–15, 1955, at the Public Auditorium in Cleveland, Ohio. The Congress was sponsored by 26 of the nation's leading engineering and scientific societies, and was coordinated by the Engineers Joint Council. The Exposition was under the sponsorship of the Amcrican Institute of Chemical Engineers. Local arrangements were handled by the Cleveland Engineering Society in cooperation with the Cleveland Technical Societies Council. More than 3,000 engineers and scientists were in attendance at the various sessions.

The keynote speaker at the All-Congress Dinner, held at the Hotel Statler on December 14, was Rear Admiral Lewis L. Strauss, chairman of the Atomic Energy Commission. Admiral Strauss carried the following message from President Eisenhower.

"To the Nuclear Engineering and Science Congress:

"To the inception of what we now call the Atomic Age many of you contributed. In Cleveland, as at Geneva last summer, you are now talking about the peacetime uses of the atom. The fact that so many are present for your Congress, representing such diverse fields of our industrial economy is, I think, ample demonstration to our people of the increasingly widespread importance of the atom in our lives.

"Since the day, 13 years ago this month when the release of atomic energy was first controlled, enormous strides have been made in its use. By 1965, I am told, peacetime atomic energy will represent an investment of many hundreds of millions of dollars. Future expansion will depend on how well we are able to add more scientific and engineering brain power to our engineering force in order to make a more productive atomic future possible.

"Educators and hundreds of others deeply interested in our schools met earlier this month in Washington to consider the problems of education. One of the major subjects considered was the increase of interest among our young people in the admittedly difficult science and engineering fields. In addition to your mission as the architects of the Atomic Age, I believe each of you can add to that task the job of helping to sell your profession to the youngsters of our nation.

"The better life for everyone, which we contemplate as a result of the peaceful application of the atom, I am convinced, is in good hands. What we need is more hands like yours."

The chairman of the Atomic Energy Commission continued with the prediction that the new source of energy would rival that of the sun. It was also warned that an international race is on to catch the "big idea" for the controlled fusion of heavy hydrogen nuclei, seawater being an abundant source.

He stressed that a shortage of engineers and scientists might well threaten the liberty of the United States and that of the free world. Technological domination of the world is the goal of the Soviets as demonstrated by their embarkation upon an ambitious scientific educational program, although their scientists are already well trained in atomic energy.

It was also pointed out that the limitless bounty of atomic energy can be sensed from the impressive displays at the Exposition and virtually every field that contributes to life, liberty, and the pursuit of happiness is represented.

Admiral Strauss also stated, "The fact is that as a nation, we face a mounting shortage of skilled manpower—a shortage which involves every field of science and engineering, and one that is particularly serious in the field of nuclear technology since the nuclear art depends upon practically all the many specialized skills of science and engineering."

It was brought out, too, that the day would come, though not for years, when a way would be found to produce nuclear power by harnessing the same energy release that we assume is taking place in the sun—

MODEL of the 180,000-kilowatt atomic power plant to be constructed by the General Electric Company near Chicago, Ill., for the Commonwealth Edison Company was a part of the General Electric exhibit at the International Atomic Exposition, held at the Public Auditorium, Cleveland, Ohio, December 10–16, 1955.

the process of the controlled fusion of light nuclei. And, unless we have the scientists and engineers in quality and numbers, the free world could lose the race.

Atomic progress—whether maintaining the advantage of our head start or falling rapidly behind—will be determined by the numbers of young people who study science and mathematics in high school and who go on to college to become scientists and engineers whose knowledge is then directed to the field of atomic energy.

A projection for the country's needs 20 years from now indicates the need for at least 23,000 engineers and scientists in the field of civilian atomic power, or nearly 5 times the present number. With the addition of the military needs, the figure is increased to more than 30,000. This would demand training 1,500 men and women per year as against less than 500, the present training figure.

The Atomic Energy Commission is cognizant of the emergency and is seeking a means of re-educating adult scientists and engineers. For in any long-range planning, the sources of supply are the colleges and universities, and few of the schools are prepared (although well aware of the need) to contribute substantially to alleviating the present and near future shortage.

Admiral Strauss cited a quotation from a speech by Deputy Premier Kaganovich of the Soviet Union in which was stated the ultimate goal of that country ". . . the victory of Communism." This goal, if attained, is defeat for Freedom. The expressed belief of the chairman of the Atomic Energy Commission is that "All of our blessings, even our freedom, could be endangered for want of enough trained minds. In this age of technology, our first line of defense is entrenched in our skill and our ingenuity and our basic knowledge."

Technical Sessions

More than 200 papers from the various sponsoring societies were presented at the 50 technical sessions conducted throughout the week at the Public Auditorium. AIEE contributed the following 13 papers:

"A Control System for Research-Type Nuclear Reactors" by E. T. Davis, V. S. Underkoffler, and R. N. Brey of Leeds and Northrup Company, Philadelphia, Pa., in which an industrial-type control system and its application to nuclear reactor control are discussed.

"Hanford Reactor Instrumentation" by E. See Day, Jr., General Electric Company, Richland, Wash., which gives a physical description of a Hanford-type reactor, together with a brief description of centralized-control philosophy and the classification of reactor-instrumentation systems and methods used in power level control.

"A Dual-Function System for Gamma Radiation Measurement" by M. B. Lebocuf, of General Electric Company, Schenectady, N. Y., and R. E. Connally and L. F. Miller of General Electric Company, Richland, Wash., describing a system which gauges the effectiveness of chemical operations in an atomic refinery by measuring radiation coming from process solutions.

"Reactor Instrumentation at Chalk River" by Albert Pearson of Atomic Energy of Canada, Ltd., Chalk River, Ont., outlining the principles behind the instrumentation program for the new reactor at Chalk River. A brief description of several instruments illustrates the advantages of the elimination of many thermionic tubes by cold-cathode trigger tubes and magnetic amplifiers.

"Dynamics and Control of Nuclear Power Plants" by A. B. Van Rennes, J. C. Simons, Jr., and T. S. Gray of Massachusetts Institute of Technology, Cambridge, Mass., which includes a study of the steady-state energy flow pattern as well as the dynamic behavior in a nuclear power plant.

"The Control of Heavy-Water Moderated Massive Fuel Reactors" by E. Siddall of Atomic Energy of Canada, Ltd., Chalk River, Ont., which discusses the characteristics of this type of reactor affecting methods of control, causes of variation in inherent reactivity, and methods of altering the net reactivity.

"Power and Temperature Control of Pressurized Water-Cooled Reactors" by W. H. Hamilton, J. N. Grace, O. R. Meyer, and N. E. Wilson of Westinghouse Electric Corporation, Pittsburgh, Pa., describing control requirements for pressurized reactors for central station plants and for ship propulsion.

"A Nuclear Reactor Simulator for Teaching Purposes" by L. Orr, W. Kerr, and H. J. Gomberg of the University of Michigan, Ann Arbor, Mich., covering the design and operation of a portable electronic nuclear reactor simulator suitable for teaching the principles and problems involved in nuclear engineering.

"The Use of Computers To Determine Time-Dependent Fission Product Distribution" by J. V. Nehemias, R. C. Dennis, J. G. Lewis, and H. A. Ohlgren of the University of Michigan, Ann Arbor, Mich., which presents the assumptions, methods, and summary results of calculations employed to estimate the time-dependent radiation characteristics of fission-product nuclides produced in the operation of a 500-megawatt (heat) nuclear reactor.

"Economic Power Fueling without U-235 Enrichment" by W. B. Lewis of Atomic Energy of Canada, Ltd., Chalk River, Ont., describing how it is possible for total power reactor fuel costs of less than 1 mill per electrical kwhr generated to be achieved from a make-up of only natural uranium, without using U-235 enriched fuel.

"Machine Sources of Ionizing Energy for Science, Medicine, and Industry" by J. G. Trump of Massachusetts Institute of Technology, Cambridge, Mass., a discussion of the operating characteristics and principles of machine accelerators of both electrostatic and electromagnetic types. Typical applications in nuclear research, treatment of disease, sterilization of drugs, and preservation of food are outlined.

"A 25-Billion Electron-Volt Proton Synchrotron" by Martin Plotkin of Brookhaven National Laboratory, Upton, N. Y., describing a proton accelerator which will achieve an energy of 25 billion electron volts, now being constructed at Brookhaven. It utilizes the relatively new principle of alternating gradient strong focusing magnet sections to guide the particles.

"The Bevatron Magnet Pulse-Timing System" by W. C. Struven of the University of California, Berkeley, Calif., a discussion of the University of California bevetron magnet-pulsing system, which provides a means of adjusting the pulse-repetition rate and the

Future Meetings of Other Societies

The Institute of Radio Engineers, National Symposium on Microwave Techniques, February 2–3, University of Pennsylvania, Philadelphia, Pa.

8th Annual Industrial Engineering Institute, Practical Developments and Application of Industrial Engineering and Management, February 3–4, simultaneously: University of California, Los Angeles, and University of California, Berkeley.

Western Winter Radio-Television and Appliance Market, division of Western Home Goods Market, February 6–10, Western Merchandise Mart, San Francisco, Calif.

11th Annual Society of the Plastics Industry Conference, Reinforced Plastics Division, February 7–9, Hotel Chalfonte-Haddon Hall, Atlantic City, N. J.

Pennsylvania Electric Association, Electrical Engineering Committee, Winter Meeting, February 9–10, Penn Harris Hotel, Harrisburg, Pa.

ASCE National Winter Convention, sponsored by Texas Section. February 13–17, Baker Hotel, Dallas, Tex.

Systems Operation Committee Winter Meeting, Pennsylvania Electric Association, February 16–17, Hotel Statler, New York, N. Y.

Annual Spring Meeting, National Society of Professional Engineers, February 17–18, Mayflower Hotel, Washington, D. C.

American Institute of Mining and Metallurgical Engineers, Annual Meeting, February 19–23, Hotel Statler and Hotel New Yorker, New York, N. Y.

12th Annual National Adequate Wiring Conference, February 23–24, LaSalle Hotel, Chicago, Ill.

Electronics Conference and Exhibit, second year, sponsored by American Management Association, February 27–29, Hotel Commodore, New York, N. Y.

American Society for Testing Materials Committee Week, February 27–March 2, Hotel Statler, Buffalo, N. Y.

Conference on Radio Interference Reduction, Armour Research Foundation of Illinois Institute of Technology, March 6–7, Technology Center, Chicago, Ill.

Passenger Car, Body and Materials Meeting, Society of Automotive Engineers, Inc., March 6–8, Hotel Statler, Detroit, Mich.

14th Annual Society of the Plastics Industry Canadian Conference, March 8–9, Sheraton-Brock Hotel, Niagara Falls, Ont., Canada

National Electrical Manufacturers Association, March 12–16, Edgewater Beach Hotel, Chicago, Ill.

National Association of Corrosion Engineers, National Conference and Exhibition, Reduction of Corrosion Losses, March 12–16, Hotel Statler, New York, N. Y.

Steel Founders' Society of America, Annual Meeting, March 15–16, Drake Hotel, Chicago, Ill.

American Trade Association Executives, Washington Conference, March 15–16, Statler Hotel, Washington, D. C.

Regional Reactive Metals Conference, Niagara Frontier Section, American Institute of Mining and Metallurgical Engineers, March 19–21, Buffalo, N. Y.

Production Meeting and Forum, Society of Automotive Engineers, March 19–21, Hotel Statler, Cleveland, Ohio.

Fifth Electrical Engineers Exhibition, Earls Court, Association of Supervising Electrical Engineers, March 20–24, London, S.W.5, England.

Symposium for Management on Applications of Analogue Computers, sponsored by Midwest Research Institute, April 10–11, University of Kansas City, Mo.

"Research for Profit" Conference, sponsored by Armour Research Foundation, April 18–20, Illinois Institute of Technology campus, Chicago, Ill.

pulse length of current flowing in the magnet. The unit also provides synchronizing pulses for the linear accelerator injector, as well as various trigger pulses before, during, and after the flow of magnet current.

Exhibits

The International Atomic Exposition, featuring exhibits by more than 100 companies and organizations, presented the newest developments in the application of atomic energy to industrial needs.

A model of the first atomic-power generating station to go into service in the United States was exhibited by ALCO Products, Inc., Schenectady, N. Y. The power plant is scheduled to go into operation early in 1957 and will be the U. S. Army's first nuclear reactor. It is designed so that its components can be transported by air to remote locations anywhere in the world.

Miniaturized nuclear control equipment, 1/20 the size of conventional equipment and using only 1/100 the power of existing units, was displayed by Daystrom Instrument Division of Daystrom, Inc., Elizabeth, N. J. The equipment is for use with mobile reactors in atomic submarines and aircraft.

Methods of harnessing the atom for peacetime use were described with three-dimensional working models of nuclear reactors for medical, industrial, and power generation applications by Atomics International, a division of North American Aviation, Inc., Los Angeles, Calif. Four models were shown at the Exposition, including two which describe reactors now in construction by Atomics International. One is a model of a medical reactor now being built for the University of California at the Los Angeles Medical Center, where it will be used for cancer therapy studies and general research in the medical field. Another model describes an industrial research reactor to be completed for the Armour Research Foundation of Chicago early this year. The reactor will be used by Armour for a wide variety of research in the industrial field. The third model is of a "pool type" research reactor in which the core, or area of the machine where fission takes place, is located under a pool of water. This arrangement will permit the research reactor to operate at power levels up to 1,000 kilowatts. The fourth model represents a sodium graphite power reactor, showing how heat from nuclear fission can be converted into electricity. Heat from the reactor core is used to produce steam, which in turn drives turbogenerators to provide electric power.

A total of eight operating atomic reactor models were displayed by the General Electric Company, Schenectady, N. Y. Included were an electromagnetic pump model, an actuator for control rods, and four reactor models which bubble and glow as onlookers manipulate dials on special panels. The exhibit also included a quick review of significant atomic developments by means of photo displays and accounts of historical highlights of atomic progress.

The complex and expensive nuclear research program being undertaken at the University of Michigan, Ann Arbor, Mich., was outlined with charts, photographs, and models. The largest facet of the Michigan program is the Phoenix Memorial Project, which includes a "swimming pool" reactor, to cost one million dollars when finished.

Television Transmitters Erupt from Mount Popocatepetl Volcano

MOUNT POPOCATEPETL, the once active Mexican volcano, is causing a new stir these days—via television.

The 18,800-foot, snow-capped peak is the location of the most powerful television transmitter in Mexico—a 45-kw station installed by Telesistemas Mexicanas, S. A., one of the largest television companies in Latin America.

The station is located some 3,000 feet below the volcano's summit at Paso de Cortez, the ancient mountain pass used by Cortez in his march to Mexico City. Its coverage is the greatest per square mile on the North American continent, extending from the Gulf of Mexico to the Pacific Ocean.

Highest television transmitter in Western Hemisphere atop extinct volcano gives greatest coverage.

Announcement of the installation, which is the highest in the Western hemisphere, was made by Federal Telecommunication Laboratories (FTL), Nutley, N. J., U.S.A., research division of International Telephone and Telegraph Corporation (IT&T). The equipment was developed by FTL and supplied through International Standard Electric Corporation, IT&T's foreign sales organization.

The transmitter is used to broadcast programs beamed via FTL's microwave radio relay link from Mexico City, some 50 miles distant. Programs originate in that capital's ultramodern television center, which maintains its own motion picture studios and includes a junior-sized auditorium with furniture specially designed for the "small fry."

Revues, operas, dramas, and motion pictures comprise the major portion of telecast programs. Also transmitted are sports events, with particular emphasis on baseball and bull fighting. These and other outdoor events are relayed to the studios by remote pickup equipment.

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AEC Special Courses and Fellowships Announced

The Special Training Division of the Institute of Nuclear Studies (ORINS), Oak Ridge, Tenn., has announced a revised course schedule for 1956 which supersedes the one published in October 1955.

The 48th through the 53rd four-week basic courses in the techniques of using radioisotopes will be conducted on the following dates:

48th	January 9–February 3
49th	February 6–March 2
50th	April 16–May 11
51st	May 14–June 8
52nd	August 6–31
53rd	September 3–28

Two-week courses in veterinary radiological health have been scheduled as follows:

10th	February 27–March 9
11th	March 12–23
12th	April 3–14
13th	June 4–15

The Division plans to hold advanced courses in the use of radioisotopes in hematological studies and procedures, May 14–18, and in general medical research and procedures, May 21–25. These two advanced courses are designed for medical personnel who have had experience in the use of radioisotopes, and will be conducted in co-operation with the ORINS Medical Division.

The Atomic Energy Commission (AEC) has made available a number of special fellowships for the academic year 1956–57 in two relatively new fields of scientific endeavor closely related to the atomic energy program—industrial hygiene and radiological physics—according to a recent announcement by the ORINS, which administers the fellowship for the AEC.

Radiological physics, or health physics, is devoted to the prevention of damage to life or property from radiation, and includes such considerations as the disposal of radioactive wastes; biological effects of radiation; the establishment of maximum permissible radiation doses; and the interaction of radiation with matter. The rapidly expanding field of industrial hygiene includes the study and control both of the more common occupational diseases and of such other environmental factors affecting employee health as radiation, heat, fatigue, and mechanical hazards associated with plant or laboratory operations.

The radiological physics program provides for an academic year of formal courses at one of three universities to which fellows may be assigned, followed by transfer to a corresponding co-operating AEC installation, where the fellows train for approximately three months in applied health physics. The three centers of the program are at the University of Rochester, in co-operation with Brookhaven National Laboratory; the University of Washington, in co-operation with Brookhaven National Laboratory; the University of Washington, in co-operation with the Hanford Works; and Vanderbilt University, in co-operation with Oak Ridge National Laboratory. The programs at all three centers will include training in modern physics, radiation biology, radiation instrumentation, industrial hygiene and toxicology, biology, and research. As many as 25 fellows may be appointed in each of the three programs which are being offered.

Industrial hygiene fellows attend either Harvard University or the University of Pittsburgh. Course work varies with the university selected and with the interests and undergraduate preparation of the individual. All fellows are required to take course work in public health and biostatistics; electives may include engineering, health physics, toxicology, industrial medicine, and related subjects.

Basic stipend for AEC fellows is $1,600, with an additional $350 allowed for spouse and $350 for each dependent child. Fellowship awards include payment of normal tuition and fees required by the university, and a travel allowance of six cents per mile for the fellow (not dependents) from the place of application to his assigned university. Radiological physics fellows receive an allowance for travel between the university and the co-operating laboratory. Industrial hygiene fellows are assisted financially to attend the annual meeting of the American Industrial Hygiene Association. One or more years of graduate work or industrial experience may qualify an industrial hygiene fellow for an additional $200 in the basic stipend.

AEC fellowship applicants may designate their choice of institutions and, when possible, assignments will be made accordingly, although the Oak Ridge Institute of Nuclear Studies cannot guarantee compliance with the choice. Requirements for AEC fellows include a bachelor's degree in physics, chemistry, or engineering, acceptability for graduate work at the university to which the fellow is assigned, and United States citizenship; applicants must be under 35 years of age. Radiological physics fellows should have minors in mathematics, biophysics, or similar fields (although applicants with other qualifications may be considered in special circumstances).

Additional information and application blanks for the special fellowships may be obtained from the Fellowship Office, University Relations Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn. All completed applications, supporting letters of reference, and transcripts must reach the Institute not later than March 1, 1956, to ensure consideration. Appointments will be made on or about March 15, 1956.

Further information concerning radioisotope courses may be obtained by writing Dr. Ralph T. Overman, Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

Exhibition at Earls Court, London

The Fifth Electrical Engineers (A.S.E.E.) Exhibition Ltd. is to be held at Earls Court, London, S.W. 5, England, March 20–24. The exhibition is being sponsored by the British Electrical Development Association, the British Electrical and Allied Manufacturers Association, the Cable Makers Association, the Central Electricity Authority, the Electrical Association for Women, the Electrical Research Association, and the Technical Press, in conjunction with the Association of Supervising Electrical Engineers.

Displays by more than 300 manufacturers will include the latest in electrical switch and distribution equipment, transformers, trunking and bus bar installations, cables and wire, switch and fusegear, switch and plug accessories, lighting fittings and lamps, ventilation equipment, blowers and fans, motors and starters, and other electrical and electronic developments.

Awards will be given to manufacturers presenting the most outstanding domestic and industrial exhibits.

For additional information on floor space, and the program for overseas visitors, contact P. A. Thorogood, General Manager, Electrical Engineers' (A.S.E.E.) Exhibition Ltd., 23 Bloomsbury Sq., London, W. C. 1, England.

Polio Vaccine Virus Killing Device Developed

Development of a highly effective device for killing virus in vaccine production has been revealed by General Motors Corporation (GM), New York, N. Y.

The device, an ingenious mechanical sterilizer, is now being used experimentally in an effort to produce a more potent and completely safe polio vaccine. A large pharmaceutical company has installed four of these purifying units and is carrying out extensive studies on polio vaccine with them.

Engineers of the GM research staff combined their efforts with medical scientists from the Michael Reese Research Foundation (MRF) of Chicago, Ill., in developing the blood-plasma vaccine sterilizer known as the "Centri-Filmer."

The Centri-Filmer spins liquid vaccine into a microscopically thin film—one ten-thousandths of an inch or one-twentieth the thickness of a human hair—so that any virus or bacteria in the liquid can be killed in a "bath" of ultraviolet light.

The device was started in 1948. During the seven-year unpublicized, detailed, and co-operative effort of the medical scientists and GM researchers, the Centri-Filmer underwent three major "model" changes. The vase-like cup in which the filmer spins was redesigned at least 12 times to achieve medically satisfactory results.

THE MEDICAL-INDUSTRIAL RESEARCH TEAM that developed a purifying device, proved highly effective for killing virus in vaccine production, is shown with the "Centri-Filmer." Left to right: Dr. Franz Oppenheimer, Michael Reese Foundation; Thomas C. VanDergrift, director, Special Problems Department, General Motors Research Staff; and Egon Benesi, senior research engineer, GM Research Staff.

Michael Reese Foundation scientists had the basic idea for the device, while mechanical and design problems for meeting its closely controlled medical specifications were assumed by the GM research staff.

General Motors research staff's technicians have produced 19 of the purifying devices for the MRF, which has distributed them to hospitals and pharmaceutical units.

The device has been used for:

1. Purification of more than a half million pints of blood plasma. One of the serious medical problems with untreated blood plasma, learned during World War II, is that it can contain an infectious virus causing a type of jaundice which results in serious illness. No such cases have been reported from plasma processed with the Centri-Filmer.

2. Purification of ACTH, used in treatment of rheumatic arthritis and many allergic eye and skin conditions. The new device demonstrated its ability to sterilize ACTH without reducing its potency.

3. Sterilization of a serum that finally wiped out hoof and mouth disease in an epidemic of that disease in Mexico which threatened to spread to the United States.

4. Purification of a rabies vaccine of greater potency than had ever been available before, according to an expert committee of the World Health Organization. The Illinois State Health Department Laboratory used one of the first Centri-Filmers built to accomplish this medical objective.

Although the principle of using ultraviolet light to kill viruses and bacteria dates back to the beginning of the century, the problem of a mechanical device to expose every particle of liquid to the same amount of ultraviolet energy was unsolved.

What medical science needed was a vibrationless mechanism that could spin liquid into such a uniform and microscopically thin film that no virus would be able to "hide" beneath another and thus escape the ultraviolet's killing rays.

Using techniques developed in balancing of automotive engines and other revolving parts, GM research staff engineers designed a perfectly balanced 15-inch vase-like cup which is spun by an accurately controlled electric motor drive.

Sterilizing action is accomplished by tubular quartz lamps that irradiate the film from inside the cup. As the film of liquid rises along the walls of the cup from centrifugal force of the spinning action, it leaves the cup at the top rim and is drawn off by a specially designed collector.

Control of the entire mechanism is extremely important because a precise amount of ultraviolet is necessary to destroy virulence of bacteria or viruses, and still leave the vaccines potent enough to activate production of antibodies when the final vaccine is introduced into the human system.

Medical experts believe that in the future many new vaccines will become possible because of the Centri-Filmer development. Among those now under experimentation are vaccines for the common cold, mumps, measles, tuberculosis, and vaccines against the viruses that cause shingles and other nerve diseases.

First Test of Smallest "Atom Smasher"

Radioactivity well logging was pushed several strides closer to positive identification and location of oil-bearing formations recently by the first successful test of the world's smallest "atom smasher" by Well Surveys, Inc., Tulsa, Okla. an affiliate of Lane-Wells Company, one of the Dresser Industries. Perfection of the miniature high energy source is one step in the application of atomic energy to oil field problems begun by the company nearly 20 years ago.

This unique neutron generator, incorporated in a standard $3^{3}/_{8}$ inch well logging assembly, is itself only 3 inches in diameter and 47 inches long, yet has been developed to provide the most intensive beam of neutrons ever used in a well. The device actually is a miniature version of a Van de Graaff particle accelerator, a large radiation-generating machine long used for physics research, cancer therapy, and more recently for chemical processing and sterilization.

The "baby" accelerator was developed and constructed for Well Surveys by High Voltage Engineering Corporation, Cambridge, Mass., designer and builder of particle accelerators. The complex instrumentation used with the neutron source was developed by Well Surveys' scientists and engineers.

Neutrons, travelling at extremely high speeds, penetrate the earth's formations surrounding a bore-hole and cause various nuclear reactions in the material encountered. These reactions, in turn, yield atomic particles and rays which can be identified and measured by sensitive radiation detection equipment which accompanies the accelerator down the hole.

The resulting information, transmitted to the surface and recorded, when correlated with the results of neutron radiation research performed with the large half-million-volt accelerator in the laboratories, will be extremely useful in the identification and evaluation of formation constituents.

Successful completion of the device is the culmination of many years' intensive effort in the uses of subnuclear particles and radiation in oil exploration. Exhaustive study of the problems involved and extensive discussion with High Voltage scientists decided the utilization of a unique joint technical effort toward this goal of perfecting equipment small enough and reliable enough to meet well-logging demands in the oil industry, as opposed to a step-by-step development.

Preliminary tests have already been run in the Well Surveys, Inc., test well at Tulsa. An intensive test program for both the neutron source and accompanying instrumentation will be accelerated through the coming months.

JAMES A. COOLEY of Well Surveys, Inc., Tulsa, Okla., assembles world's smallest "atom smasher" at well head. Miniature neutron generator used in well logging studies was developed and constructed by High Voltage Engineering Corporation, Cambridge, Mass. Instrumentation used was designed by scientists and engineers at Well Surveys.

Largest Lathe Installed for Future Jobs

One of the biggest lathes in the world—144-inch swing and 55 feet between centers—has been installed in the General Electric Company's (GE) large motor and generator department, Schenectady, N. Y.

The Betts-Bridgeford lathe was built by the Consolidated Machine Tool Corporation, Rochester, N. Y., a division of the Farrel-Birmingham Company, and cost GE ". . . about half a million dollars."

The new tool is part of the expansion and modernization program, designed to equip the department to meet the expected pro-

duction needs of the next 10 years, and beyond. The company expects demand for electrical equipment to double before the decade is over.

Looking to the future, GE ordered a lathe bigger than needed for any job now under way, foreseeing a demand for ever bigger hydraulic turbine-driven generators, direct-current motors, flywheels, and other rotating equipment for utilities and industry.

Feature of the new tool that will be needed soonest is the 144" swing. GE design engineers were previously limited by the 120" swing of the shop's largest lathe.

The new lathe's tracks, bearings, drives, and controls are designed for precision.

The live tailstock quill center is accurate to a total indicated runout of 0.0005 inch. All-electronic longitudinal and cross feeds permit feed setting at any increment from 0.002 inch to 0.75 inch per spindle revolution. The machine can carry jobs weighing up to 200 tons at speeds ranging from one half to 40 rpm. Centers alone will carry 200-ton loads at slow speed.

Bedways and carriage ways are of hardened steel, ground and polished. Renewable bronze liners are provided on both mating surfaces of the carriage cross slide and on the top mating surfaces of the auxiliary top slide and the swivel. Tailstock bearings and carriage apron shoe bearings are bronze.

An adjustable panel beside the operator's platform on the carriage contains pushbutton controls for starting and stopping, spindle speed regulation, and adjusting speed and direction of tool travel.

Automatic limit switches at the ends of all travel ways prevent overtravel.

Main drive is a GE adjustable-speed direct-current motor, 150/200 hp, dripproof, blower ventilated, and rated for continuous use from 60 to 300 rpm at constant torque and 300 to 1,200 rpm at constant hp.

A motor generator set provides 540 amps at 230 volts, dc, from 3-phase, 60-cycle, ac line current at 200 amps, 550 volts.

Nine other motors, ranging down to 1/4 hp, power the various carriage and tailstock drives, blowers, lubricant pumps, and a chip conveyor.

Chips drop to a shake-type conveyor between the bedways, and then travel past the tailstock to an elevator that empties them into waste bins.

The cast iron faceplate, 10 feet in diameter and weighing (with its shaft) about 20 tons, is so finely balanced and lubricated that a man can turn it by hand.

Joint Fellowships in Systems Engineering Announced

Fellowships in systems engineering for the academic year 1956–1957 have been announced by the Ramo-Wooldridge Corporation in co-operation with the California Institute of Technology and the Massachusetts Institute of Technology.

The program for each Fellow covers a 12-month period and will provide the recipient with an opportunity to pursue a broad course of fundamental study as well as an opportunity to associate and work with successful engineers and physicists in the field of systems engineering which include the techniques and practice of operations research. The growing need in modern industry is for individuals trained to attack and solve advanced design problems involving the complex relationship between electrical, mechanical, aeronautical, and chemical portions of complete systems.

The award winners will be expected to begin the year's program in July 1956, with about 8 to 10 weeks of advanced development work at Ramo-Wooldridge. The remainder of the time will be spent at the California Institute of Technology or Massachusetts Institute of Technology working toward a Doctor's degree or in post doctoral study.

The full-time course of study will include a wide selection of fundamental courses in mathematics, physics, applied mechanics, aeronautics, electrical engineering, mechanical engineering, and industrial management, as well as special courses aimed specifically at bringing the systems engineering objective into sharper and more direct focus.

The work would be directed toward the Ph.D. or Sc.D. degree in engineering science, aeronautics, physics, electrical engineering, mechanical engineering, or in other appropriate designations, as offered by each institution.

Each fellow will receive a cash award of $2,000, or more, depending on family responsibilities, plus a salary of about $2,000 for summer and part-time work at the Ramo-Wooldridge Corporation. A grant of $2,100 for each Fellowship will go to the institute involved, covering tuition and research expenses.

Any United States citizen is eligible whose qualifications and background will admit him to the graduate school either of California Institute of Technology or Massachusetts Institute of Technology, and who has completed one year of graduate study in mathematics, engineering or science, before the beginning date of the Fellowship.

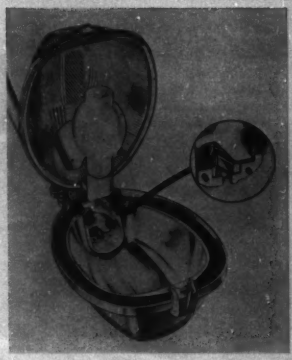
Application may be obtained by writing to The Ramo-Wooldridge Fellowship Committee, The Ramo-Wooldridge Corporation, 8820 Bellanca Avenue, Los Angeles 45, California.

Beryllium Used in Lamps for Outdoor Settings

An Ovalite luminaire manufactured by the Line Material Company (L-M), Milwaukee, Wis., for outdoor installations where wide distribution patterns of high light intensity are needed, is equipped with a service-safe disconnecting socket—the socket is removed automatically from the electrical circuit when the lamp is opened and the bulb placed in an easily accessible position for replacement.

There is no arcing, even though the socket is withdrawn while the lamp is energized. This feature is available in both the series and multiple circuit luminaires.

In the series type luminaire, when the glassware assembly is being hinged closed, a make-before-break action occurs. The socket is shunted while the bayonet blade is being inserted into the receptacle contacts to prevent arcing.



The receptacle contacts are made of silver-plated "Berylco" brand beryllium copper, selected by L-M engineers because beryllium copper retains its excellent spring characteristics, such as good tensile and yield strength, even at high temperatures. Since the contacts are directly in contact with the lamp socket within a closed space, the temperatures are often sufficiently high to cause some contact materials to lose strength. "Berylco" beryllium copper was also specified because it is noncorrosive, and in this case, the beryllium copper strip supplied needed no heat treatment by the fabricator.

Doctors and Engineers Study Bone and Metal Splints

Two Yale faculty members, one a medical authority on bones and the second an engineering expert, have joined forces in an unique study of "bone engineering."

Under the direction of Dr. Charles O. Bechtol, Associate Professor of Orthopedic Surgery at the Yale School of Medicine, the research work is aimed toward defining the characteristics of bone. Eventual goal is the perfecting of a bone splint for the healing of severe fractures.

From the Yale School of Engineering, the project has drawn Henry A. Lepper, Jr., Associate Professor of Civil Engineering, to handle the technological side of the experiments.

The materials used in studying the problem of splints are bone and metal, which must be understood thoroughly. Bone splints in use today are made of either vitallium or stainless steel, and are fastened to bones by means of screws inserted in holes which have been drilled into the bone on opposite sides of the fracture.

But, few doctors are convinced of the complete success of this type of operation, according to Dr. Bechtol. It has been found in the engineering lab that drilling holes in bones reduces strength by as much as one third.

Supported by a grant from the Erdle-Prange Foundation, the study of "hows" and "whys" of bone and of metal behavior is being made. In the laboratory of the Civil

TRACKING AN AERIAL TARGET (above), the Sperry Mark 63 gunfire control system foreground, supplies an automatically computed lead angle for the three-inch guns in the background. Action took place at Fleet Training Center, Newport, R. I. GUN CONTROL "TALKER" (left) maintains contact with gun crew while operator tracks a target with Sperry Mark 63 gunfire control system. This Navy system utilizes radar data to compute necessary lead angle automatically.

Engineering Department, bones are subjected to a variety of pressures and tests, then drilled and subjected to the same tests again, to determine the inherent strengths and weaknesses.

University civil engineers and medical researchers have also found that any bone is more than strong enough for its particular function, it is extremely difficult to design and install a bone splint which can absorb the same stresses as the bone to which it is attached. For example, a person standing on one leg imposes on the corresponding hip joint a weight two and a half times his body weight, or in the person of a 200 pound man standing on his right foot, a weight of 500 pounds is imposed on his right hip. This is so because of "body engineering" with various interconnections between the bones and muscles of the body.

It has been found, too, that the bones of the leg have a safety factor of about 30. Here, the figure of 30 means that the bones of the leg will withstand pressures 30 times those caused in normal use, and that designing and installing a lightweight brace with the same safety factor is not an easy task.

"Bones are remarkable structures as far as design goes," says the Yale doctor, "and nature won't let you tamper with them to any great extent." But even with their remarkable "economy of design," bones fortunately are the strongest where the pressures on them are the greatest. By the nature of their substance, however, bones pose engineering problems of no small scale. Bone substance has an amazing amount of flexibility—up to a point. Beyond that point they are exceedingly brittle. Then too, if abnormal constricting pressures are applied to the bone, it disintegrates in a very short time.

Thus, any type of splint must be applied only on one side of the bone—and this of course increases the difficulty of designing splints that are strong enough to provide the needed support, yet light enough to avoid complications. The resort to engineering helped found, for example, that narrowing the center section of a particular splint weakens it severely. Yet by routing out the center section of the same splint, actually strengthens it.

The Yale doctors and engineers have also found that if the screws used to fasten the splint to the bone are small enough to avoid weakening the bone appreciably, they may be too small to withstand normal pressures on them.

Yet with all attendant puzzles, the problem of bone splinting is one that cannot be ignored or avoided, because bone splints are necessary on fractures requiring considerable length of time to heal. Because soft tissues, if held motionless for any length of time, are subject to permanent stiffness, a fracture of the thigh bone may require as much as six months to one year to heal completely. If the entire limb is enclosed in a cast for that length of time, permanent stiffness is a "definite possibility." Thus the bone splint for fractured limb which should be used as much as possible.

Casts probably will always be used for some fractures, especially minor ones, but more serious fractures do require bone splints for successful healing. Because of the practical nature of the problem, the Yale engineers and doctors have conferred with the research division of the American Screw Company, Willimantic, Conn., which is experienced in industrial screw design and made a number of experimental screw types for the university members.

U. S. Navy Reveals Mark *63* Gunfire Control

First details of the United States Navy's Mark *63* gunfire control system, capable of tracking speedy jet aircraft with 3-inch and 5-inch naval guns in any weather, were disclosed today.

The system's purpose, and extensive operational use by Allied fleets "for some time," were revealed by announcement of current follow-on contracts with the Sperry Gyroscope Company, for further manufacture of the director gear. Present production orders call for a total of "more than $4 million" of Mark *63* gunfire control systems and spares, for continuing use in combat vessels of the United States and Allied fleets.

Jet capability of the Mark *63* system results from combining newer gunfire controls and radars with the gyro-optical tracking principles of World War II gunsights, the Sperry Mark *14* and Mark *15*. Radar ranging and high speed computation, among other advances, give Mark *63* anti-aircraft batteries improved accuracy at both low and medium altitudes, where modern sonic speeds are most difficult to follow, according to veteran gunners who are now instructors of the Sperry system at Fleet Training Center, Newport Naval Base.

In the present system, visual gyro tracking is backstopped with radar for low-visibility conditions, while the radar also supplies instantaneous range and speed information. From this data, automatic computers predict needed lead angle and elevation, as mechanical "muscles" swing the guns in response to the signals received. Such systems were evolved over many years in a close collaboration of Sperry research with technical experts of the Navy's Bureau of Ordnance.

The history of predecessor equipment, the once secret Mark *14* gunsight, dates from Pacific combat success of that device in October 1942. At Navy request, Sperry assisted other major industries to begin manufacture of this critical gear, and before the war's end over 50,000 Mark *14* sights were supplied to United States and British naval and merchant vessels. When fighting broke

out in Korea, early versions of a later "Mark 63" system were ready for use by the U. S. Navy.

Electrodes Implanted in Brain for Study by Scientist

Dr. Jose M. R. Delgado, Associate Professor of Physiology and Psychology at the Yale School of Medicine, gave his report on how implanting very thin electrodes in the human brain can serve as a valuable aid in the diagnosis of epilepsy at the Eastern Association of Electroencephalographers meeting at the New York University-Bellevue Medical Center, New York, N. Y. With his associate, Dr. Hannibal Hamlin, of Providence, R.I., Dr. Delgado has made electrode diagnoses of eight patients with severe psychomotor epilepsy.

The implanting of the electrodes, a relatively simple operation, permits the doctor to pinpoint with a high degree of accuracy those specific areas of the brain with abnormal activity. Once these areas have been identified, surgical treatment can be applied.

Up to 42 electrodes, thin silver wires measuring only 0.005 inch in diameter, are first implanted in the brain under local anesthesia. The presence of the electrodes in the brain is not painful nor does it produce any disturbances.

The electrodes are connected by wires to special equipment to record the electrical activity of the brain. The period of diagnosis may run from two to four days, then the electrodes are removed quickly and simply, according to Dr. Delgado.

This electrode method is more accurate than the regular electroencephalography (EEG) method, in such diagnosis, the Yale scientist said. In the EEG method, the electrodes are placed against the scalp.

Implanted electrode recordings show clearly and accurately those areas of the brain with abnormal activity. During some of the diagnoses, patients actually have undergone spontaneous epileptic seizures and the recordings graphically illustrated the unusual brain-wave activity of these seizures.

The recordings also show that there is a definite pattern identifying warning symptoms felt by patients during the onset of a seizure. Even after the patient regains consciousness following a seizure, the recordings show that brain activity is still grossly disturbed for a brief time.

The doctors also have used the implanted electrodes in the brain for transmitting very mild electrical stimulation to various areas in the brain, to study excitability of these areas. It was found that in some cases stimulation produced illusions in the patients in that they heard imaginary voices or saw imaginary faces.

Electric Engineers Co-operate for Public Good

The most far-reaching example of co-operation by many top-ranking professional engineers for the benefit of industry and the public was reported in Ottawa, Ont., Canada. The results of this giant co-operative effort, which affects the technical and economic utilization of the radio airwaves, were examined in detail at the Eleventh Annual Meeting of the Canadian Radio Technical Planning Board.

Without parallel in the history of engineering development in Canada many electronic specialists met at this meeting, on an entirely voluntary basis, to consider recommendations made by engineers meeting during the past year, at their own expense, to make certain that the radio airwaves, which are in the public domain, will provide for the rapidly increasing number of radio and allied services. The results of these deliberations will undoubtedly reflect in clearer television reception and better radio listening in the homes of Canadians.

The Canadian Radio Technical Planning Board was formed to make recommendations to the government and to industry for the conservation and efficient use of the radio spectrum, or the channels of communication, by proper forward planning and improved design of equipment which will, in turn, provide more channels of communication for the public service.

U. S. Army Purchases "Bizmac" for $4 Million

Purchase by the United States Army of a $4-million electronic data-processing system, "Bizmac," that converts months of business paperwork into minutes of "push-button" operations was announced today by Frank M. Folsom, president, Radio Corporation of America (RCA), and Brig. Gen. Nelson M. Lynde, Commanding General, U. S. Army Ordnance Tank-Automotive Command (OTAC), Detroit, Mich.

Delivery of the "Bizmac" system to OTAC-Detroit is now under way. It will be utilized for electronic stock control of replacement parts for military combat and transport vehicles.

The "Bizmac" system incorporates approximately 200 units of 13 different but fully integrated types of electronic equipment. The system is designed to perform electronically most of the voluminous clerical procedures involved in OTAC's world-wide stock control program. With lightning speed and accounting accuracy, "Bizmac" will:

1. File on a single reel of magnetic tape, $10\frac{1}{2}$ inches in diameter, more than 2.5 million characters—or all the information contained in approximately 8,500 of OTAC's parts inventory records.

2. Electronically "read" and "write" at the rate of 10,000 letters or digits per second; operate at a tape speed of 80 inches per second.

3. Add, subtract, multiply, and divide with electronic speed, and "remember" specified information indefinitely for recall in a few millionths of a second.

4. At a speed of 600 lines a minute, print OTAC's inventory procurement recommendations, shipping orders, and other business paperwork involved in the operation of the parts control program.

Nerve center of the computer is a magnetic core memory matrix—a small, economical, highly reliable assembly of copper wires and magnetic washers developed by the David Sarnoff Research Center of RCA, Princeton, N. J. Operating as an "electronic scratchpad," the high-speed memory can "remember" its stored information indefinitely and, on signal, release it in a few millionths of a second.

The complete "Bizmac" system includes input devices, for preparing and feeding information and instructions into the system; storage devices, for filing data within the system so that it is readily accessible on demand; processing devices, for sorting and filing information, computing, and performing business arithmetic as dictated by instructions; and output devices, for providing finished copies of information as desired.

BIZMAC, RCA-developed electronic data-processing system, purchased by U. S. Army for $4 million, will do in minutes inventory control procedures now requiring months at Ordnance Tank-Automotive Command, Detroit. Arthur L. Malcarney, general manager, Commercial Electronic Products, RCA, discusses with Brig. Gen. Nelson M. Lynde, Commanding General, OTAC-Detroit, the system's computer which operates unattended; adds, subtracts multiplies, and divides with electronic speed; and "remembers" stored information indefinitely and, on signal, releases it in a few millionths of a second.

Automation Meeting and Exhibit to Be Held in Paris

The French Association of Electronic Engineers has organized a meeting to be held in Paris, France, June 18–24, at which questions related to "Automatics" will be discussed.

The program committee has asked for and received the co-operation of many prominent French scientists and technicians, as well as others from different countries who plan to participate in the various sessions scheduled.

The term "Automatics" is defined, though not too clearly, as the science of automatic operation. "Automation," on the other hand, is the actual application of automatics to industrial production.

Inasmuch as all engineers must eventually become conscious of the importance of automation, this congress will try to cover its many aspects.

An exhibition will display the achievements in industry to date.

The meeting will be divided into two topical sections. The subject of "Automatics" will be discussed in the presentation of a Definition of Automatics; Present Theoretical Concepts—engineering point of view, and electronics point of view; and Fields of Application—technical, scientific, and economic. That of "Automation" will be taken up by Relation between Automation and Production, which will give a definition of "Automation"; Theoretical Bases of Automation; The *Functional* Structure of Automatic Production; The Technical Structure of Automatic Production; Fields of Application; Effects on Production—from a technical point of view (productivity, quality), from the economic point of view, and from the social point of view.

Interested parties should write to: Secrétariat du Colloque sur l'Automatique, Chaire de Mécanique, Conservatoire National des Arts et Métiers, 292 Rue Saint-Martin, Paris (III°), France.

Display Previews All-Electronic Hotel

The electronic hotel, in which computers applying the principles of so-called mechanical brains will automatically—and flawlessly—register guests, assign rooms, sort mail, route messages, and prepare bills, was foreshadowed recently in the exhibit of Minneapolis-Honeywell Regulator Company at the American Hotel Association convention in New York, N. Y.

From the time the guest disembarks in front of the hotel a host of robot aids will operate to speed him to his room. The first automatic assist will probably come in the form of a built-in conveyor system which will transport baggage inside, and later to the floor assigned the guest.

Once the guest is guided into his room by the computer-staffed registration desk—monitored by a human receptionist—his comfort will be a matter of button pushing. For example, a bedside console will offer an array of buttons which will permit automatic temperature adjustment, whether for heating or cooling; remote operation of either radio or television; pushbutton selection for the time of the morning call; remote operation of all lights; and remote locking of door. The console will also collect messages, handle phone calls, and give news and weather reports.

It may be feasible to lace the hotel with a network of pneumatic tubes used for almost instantaneous delivery of standard room-service items such as ice, newspapers, and food.

Elevator service will be automatically improved by adoption of new electronically controlled elevators geared to traffic flow, similar to those now installed in modern office skyscrapers.

The effect of this hotel automation of the hotel staff—from room clerk to bellboy—will change the nature of their jobs, not displace them. In the electronic hotel, the primary job of the human will be one of supervision and guidance for the automatic devices, for a hotel would be a pretty friendless place without humans to give it warmth and a personality, it was pointed out.

Stanford Offers Electronics Fellowships and Assistantships

Financial assistance in several forms is available to well-qualified graduate students who wish to work toward higher degrees, with a special interest in electronics, by Stanford University through its electronics research laboratory, radio propagation laboratory, applied electronics laboratory, and microwave laboratory.

The integrated programs of course work are aimed at providing the engineering, physics, and mathematics student with a broad preparation in fundamentals.

Application forms and university bulletins may be obtained by writing to the Assistantship Committee, Electrical Engineering Dept., Stanford University, Stanford, Calif.

Industrial Television Transmitted via Telephone

Photographs, printed material, and signatures were transmitted over 10 miles of ordinary telephone lines in the first public demonstration of an industrial television system which operates without costly video pairs, microwave, or coaxial cables.

The demonstration was staged jointly by The Bell Telephone Company of Pennsylvania, which will offer the industrial television service to customers in metropolitan areas, and by the Dage Television Division, Thompson Products, Inc., Michigan City, Ind., manufacturers of industrial television equipment, which developed the system.

Called Data-Vision, the new television system will be used experimentally by the Philadelphia National Bank from its office at 421 Chestnut Street to its office at 1416 Chestnut Street.

Data-Vision makes possible at low cost almost instantaneous signature verification for branch banking. It has many other potential applications in business and industry—wherever there is a need to view at a distance any type of visual information such as pictures, printed or written material, meters, gauges, etc.

In addition to the banking field, Data-Vision may find use in communications between outlying industrial plants and mid-city offices, transportation and warehouse installations, chain stores, hospitals, police stations, and other Government offices.

In the demonstration in Philadelphia's Bellevue-Stratford Hotel, the Data-Vision camera and monitor at the sending end stood within a few feet of the receiver but the material transmitted between them travelled 10 miles.

Developed by Dage during an intensive two-year research program, Data-Vision employs a slow-scan transmitter which completes the picture on the screen within two to four seconds. The monitor and receiver used Radarvision tubes which hold the slowly transmitted image long enough for it to be clearly read or photographed.

The Data-Vision camera—about the size of a box camera—picks up any material placed before it. The image appears on the six- by two-inch viewing screens on the monitor and the receiver.

The important point about Data-Vision is the relatively inexpensive medium used to transmit the picture information between the camera at the originating point and the receiver. Ordinary industrial television requires the transmission of a band of frequencies 4-million cycles wide whereas Data-Vision requires only an 8,000-cycle bandwidth.

The equipment demonstrated in Philadelphia is now in production, and will be ready for deliveries as soon as field tests are completed at the Philadelphia National Bank.

Some of the goals sought are a brighter more detailed picture, elimination of the bright scanning line which crosses the screen once every two seconds to renew the picture, extension of the practical sending range now limited to 25 miles (experiments with round-trip circuits between Philadelphia and New York City have been satisfactory under special conditions).

Although the screen used in the demonstration is particularly suitable for signature identification, other screen sizes will be available. Dage now has a model with a $5^1/_4$- by 4-inch screen.

Longer circuits may be provided in the future, depending upon demand and the results of further tests.

Carnegie Institute Gives Graduate Study and Research Aid

The Carnegie Institute of Technology is offering assistantships for teaching and research, and graduate fellowships for the academic year 1956–57, with opportunities leading to degrees of master of science and doctor of philosophy in chemical engineering, chemistry, civil engineering, electrical engineering, mathematics, mechanical engineering, metallurgical engineering, and physics.

Applications will be considered from qualified students who wish to begin or return to graduate study in the Fall of 1956. It is possible for candidates to apply for forms and information by writing to the Dean of Graduate Studies, Carnegie Institute of Technology, Schenley Park, Pittsburgh, Pa.

Unique Design Battery Developed

A new type of battery which gives more output per pound was announced by the Air Research and Development Command (ARDC) Headquarters, Baltimore, Md.

Unique in design and construction, the new silver oxide zinc battery employs a "pile" type construction instead of the conventional plate type construction.

Designed by the Raleigh (N.C.) Engineering Laboratories of the American Machine and Foundry Company under contract with ARDC's Rome (N.Y.) Air Development Center at Griffiss Air Force Base, the new type battery will be used for powering special electronic equipment.

In pile type construction, each cell is an individual battery which prevents intercell action due to contact between cells through the electrolyte. With this type of construction an individual filler hole per cell is required. In a dry-charged condition they are capable of shelf storage for months.

The dry-charged system is activated manually by a vacuum pump and special reservoir units which have hypodermic type needles for piercing the cell seals. A valve is tripped automatically to allow the proper amount of electrolyte into the battery. This procedure insures rapid and complete wetting of all portions of both the positive and the negative elements.

The pile type designs have been constructed in sizes of 0.1, 3.0, and 12.0 ampere hours. The latter size shows a yield of over 70 ampere hours per pound and 5 watt hours per cubic inch. High efficiency performances are realized down to 32 F.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE AUTOMATIC FACTORY—WHAT DOES IT MEAN? (Report of Conference, Margate, June 1955). The Institute of Production Engineers, London, 1955. 228 pages, 11¼ by 8½ inches, bound. 25/g. The papers in this report present a broad review of the technical and human problems of automation, with particular reference to implications for the British Economy. The impact of the automatic factory on management, labor, engineering schools, and society generally are dealt with in some of the papers; others discuss such subjects as automatic transfer machines, automatic inspection, computer-controlled machine tools, automatic control in the petroleum industry, automatic linking devices, and automatic selection, weighing, and conveying. Descriptions of equipment displayed at the conference are included.

BASIC ELECTROTECHNICS. By B. L. Goodlet. Edward Arnold Ltd., London (distributed in U. S. by St. Martin's Press, Inc., 103 Park Avenue, New York 17, N. Y.,) second edition, 1955. 277 pages, 8½ by 5½ inches, bound. $5.25. A concise presentation of basic information on steady and alternating currents, electrostatics, electrodynamics, magnetic field calculations, transient phenomena, Maxwell's equations, and electro magnetic waves. The treatment presupposes a knowledge of physics, calculus, and the construction of electrical apparatus, and employs only M.K.S. rationalized units.

CHEMICAL PROCESSING AND EQUIPMENT. United States Atomic Energy Commission. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1955. 302 pages, 10½ by 8 inches, bound. $6. One of a series of reports prepared for the International Conference on the Peaceful Uses of Atomic Energy, this volume includes a brief review of the facilities, equipment, and process initially provided at the Idaho Chemical Processing Plant for uranium recovery from uranium-aluminum alloy fuels such as those used in the materials-testing reactor and the bulk-shielding reactor. More than five-sixths of the book is devoted to the application, description, and operation of laboratory equipment for the handling of highly radioactive materials, and to discussion of the layout of an existing laboratory.

DMP—DIMENSIONAL MOTION TIMES. Development and Application. By H. C. Geppinger. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1955. 100 pages, 11 by 8½ inches, paper. $4. This is a report of a research project undertaken to develop a systematic procedure for analyzing work in terms of motions, and for measuring the work content by predetermined time values which are related to distances and other dimensional terms. The report includes a summary of the development of the system, five tables of data by which factory operations may be determined, and examples of typical applications.

EINFÜHRUNG IN DIE THEORETISCHE ELEKTROTECHNIK. By Karl Küpfmüller. Spring-Verlag, Berlin, fifth edition, 1955. 473 pages, 10 by 6¾ inches, bound. DM 27.60. This introduction to theoretical electrical engineering is intended to provide a groundwork in the concepts and methods of analysis basic to further study in the fields of power, communications, and electronic engineering. Analytical methods are illustrated by practical, numerical examples.

ELECTRIC POWER STATIONS. Volume II. By T. H. Carr. Chapman & Hall, Ltd., London, fourth edition, 1955. 832 pages, 8¼ by 5½ inches, bound. 80s. This second volume of the two-volume treatise on the design, construction, and operation of electric power stations deals especially with the electrical side of the subject-alternators, transformers, reactors, switchgear, cabling, and protective equipment. Three chapters deal with hydroelectric, diesel-electric, and gas turbine plants, and there is a chapter on wind, atomic, and other power plants. Also covered are lubricating, insulating, and fuel oils; auxiliaries; station organization; and costs.

ELECTRICAL MEASUREMENTS AND MEASURING INSTRUMENTS. By E. W. Golding. Pitman Publishing Corporation, 2 West 45th Street, New York 19, N. Y., fourth edition, 1955. 913 pages, 8½ by 5½ inches, bound. $10. The theory and use of an extensive range of measuring instruments and methods are comprehensively covered in this book intended for electrical engineers in general and for students preparing for certain British examinations. In this revision new material is included on illumination, high-voltage measurements, cathode-ray oscillography, La Place transformations, and other subjects, and a chapter on electronic measuring devices has been added.

ÉLECTRONIQUE INDUSTRIELLE. By G. Goudet Editions Eyrolles, Paris, 1955. 635 pages, 9¾ by 6½ inches, bound. F fr. 5,500. This new text begins with a concise treatment of fundamental electrical circuits and the characteristics of electron tubes, both vacuum and gas-filled. The next two sections cover amplification methods and the production and detection of electrical signals. The latter part of the book deals with specific applications of basic telecommunication elements in industry: high-frequency heating, photoelectric cells, servomechanisms, etc. Also considered are such topics as semiconductors, electron diffraction, the mass spectroscope, ultrasonics, and the electron microscope.

ELEKTRONIK DES EINZELELEKTRONS. By Franz Ollendorff. Springer-Verlag, Vienna, 1955. 643 pages, 9¾ by 6¾ inches, bound. $23.10. A textbook for advanced students of physics and electrical engineering which deals with the "electronics of single electrons," or the action of a single electron in electrostatic and magnetostatic fields such as are basic to cathode-ray tubes and similar devices. Chapters are also devoted to classical analytical mechanics as applied to single electrons, to electron optics, and to other specialized aspects.

GUIDANCE. By Arthur S. Locke. D. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y., 1955. 729 pages, 9½ by 6¾ inches, bound. $12.50. This volume, one in a series entitled Principles of Guided Missile Design, treats the devices and techniques used to guide missiles. It includes basic information drawn entirely from unclassified literature on fundamental problems; locating targets by infrared, radio, and acoustic waves; fixing targets by terrestrial or celestial reference; and the mathematics essential for solving guidance problems, among the subjects covered for solving guidance problems. The other subjects covered are related servo systems theory, analysis of flight trajectories, and analogue and digital simulation.

HÜTTE-DES INGENIEURS TASCHENBUCH. Volume I—Theoretische Grundlagen. Edited by Akademischen Verein Hütte. Wilhelm Ernst and Sohn, Berlin, twenty-eighth edition, 1955. 1,668 pages, 7¼ by 5 inches, bound. DM 56. A comprehensive handbook of engineering fundamentals, this volume includes separate sections on mathematics, physics, heat, vibration, mechanics, strength of materials, chemical and physical properties of metals and nonmetals, and measurements. An appendix gives conversion tables for the American, English, and metric systems. Extensive additions have been made to the material of the previous edition.

HÜTTE-DES INGENIEURS TASCHENBUCH. Volume VB: Verkehrstechnik, part 1 and Vermessungstechnik. Edited by Akademischen Verein Hütte. Wilhelm Ernst and Sohn, Berlin, twenty-eighth edition, 1955. 588 pages, 7¼ by 5 inches, bound. DM 36. The two parts of this volume are devoted to railway engineering and surveying. Part one presents basic data on railway construction and operations, station design, roadbeds, track, electrical and mechanical equipment, cars, locomotives, and related subjects. Part two covers surveying instruments and methods and photogrammetry.

THE INDUSTRIAL TRIANGLE. By Fred H. Colvin. Columbia Graphs, Columbia, Conn., 1955. 172 pages, 8¼ by 5½ inches, bound. $3.50. The author considers a series of topics involving the interrelationship of the three factors that ensure profitable and continuous production: proper machine equipment, efficient management, and dependable labor. The discussion covers such subjects as annual wages, incentives, feather bedding, and automation as it affects labor and management. Practical suggestions for maintaining industrial peace are made to both management and labor.

INSTRUMENT ENGINEERING. Volume III:, Applications of the Instrument Engineering Method. Part 1: Measurement Systems. By Charles Stark Draper, Walter McKay and Sidney Lees. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 879 pages, 11½ by 8½ inches, bound. $17.50. This volume contains examples in which the theory, methods, and techniques described in the first two volumes are applied to specific measurement problems. The discussion deals with instruments ranging from thermometers with the simplest possible performance equations to vibration measuring equipment and covers electromechanical devices, pressure-measuring systems, integrators and differentiators, and analogue computers.

INSTRUMENTS FOR MEASUREMENT AND CONTROL. By Werner G. Holzbock. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1955. 371 pages, 9 by 6 inches, bound. $10. Nine chapters of this book are devoted to descriptions of the operational characteristics and, in many cases, the structural details of instruments commonly used in industrial plants for measuring temperature, humidity, pressure, flow, and other process variables. Five chapters deal with various control devices—electric, pneumatic, hydraulic, etc.—and the last chapter briefly summarizes recent trends in the use of centralized control systems.

AN INTRODUCTION TO PROCESS CONTROL SYSTEM DESIGN. By A. J. Young. Longmans, Green and Company, Inc., 55 Fifth Avenue, New York 3, N. Y., 1955. 378 pages, 8¼ by 5½ inches, bound. $8. A treatment of basic principles using the frequency response approach and employing only the necessary minimum of mathematics. Descriptions of various types of controllers and control systems are given, and methods for the calculation of their characteristics shown. The analysis of plant characteristics is also dealt with as a basis for design of controls for more efficient production both in existing and new plants.

TH LINEMAN'S HANDBOOK. By Edwin B. Kurtz. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., third edition, 1955. Various paging, 8½ by 5½ inches, bound.

$8.50. Considerably revised and enlarged over the previous edition, this handbook gives an easily understandable presentation of procedures and methods of line construction, accompanied by an introductory explanation, of electrical principles and electric systems. Throughout the text pertinent requirements of the National Electric Safety Code are quoted.

DIE PHYSIKALISCHEN GRUNDLAGEN DER HOCHFREQUENZTECHNIK. Edited by Hans Georg Möller. Springer-Verlag, Berlin, third edition, 1955. 261 pages, 9¼ by 6¼ inches, bound, DM 29.70. This first volume of a projected 5-volume "Textbook on Radio Engineering" presents the basic physics and mathematics required for a thorough comprehension of the special subjects to be covered in the subsequent volumes, which are as follows: electromagnetic wave production and reception, electron tube elements and characteristics, amplifiers and receivers, and television engineering. It also gives a general survey of high-frequency techniques.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Wire Up and Live—Electrically. A presentation of the basic facts about adequate wiring in a unique new style of words-and-graphics called "scriptography." Scriptography has already proved its worth on many another tough assignment in the communications field it is claimed. The U. S. Army uses it to explain the new Reserve Law and to promote re-enlistments. The Social Security Administration and the Department of Commerce are also using scriptographic booklets to communicate complicated messages to the public. This 2-color booklet uses a minimum of words and a liberal use of graphics and cartoons. Designed as an introduction to the subject, the booklet lists other and more comprehensive presentations of the adequate wiring story for the home-owner who is interested in improving his home wiring. The back copy is available for imprinting. 16 pages. 15¢ each. Available in bulk quantities at 10¢ each for 2 to 99 copies 8¢ each for 100 to 999 7¢ each for 1,000 to 9,999 and 6¢ each for 10,000 or more. Order from Channing L. Bete Company, Inc., Greenfield, Mass.

1955 Book of ASTM Standards: Part 1—Ferrous Metals. The American Society for Testing Materials has just issued Part 1—Ferrous Metals of its 1955 Book of ASTM Standards, which contains 125 standards that are new or have been revised since the 1954 Supplement was published a year ago. Since 1952, 211 standards are new or have been revised. Part 1 contains standard and tentative specifications, methods of test, and definitions for steel piping materials; flat products; bars, bolts, and rivets; billets, forgings, and axles; rails and accessories; railroad wheels; springs; concrete reinforcement; corrosion-resisting steel; metallic coatings for steels; welding rods; wrought iron; cast iron; malleable iron; magnetic materials; ferro alloys; and metal powders; as well as general methods of testing. It is especially important in the heavy machinery, railroad, and construction industries. Materials engineers, purchasing agents, and others concerned will need the new Part 1 to assure their using the latest applicable standards. The remaining parts of the 1955 Book of ASTM Standards will be published by the society as rapidly as the editorial and press work can be completed, with the last part expected off the presses about February 1956. Part I contains 1,834 pages with 315 standards. Part I which is on Bible type paper with blue cloth covers and red backstrap costs $13.50 per copy. The price of the complete seven-part 1955 Book of ASTM Standards is $84. Available from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa.

New Shop Techniques and Devices. New Shop Techniques and Devices, PB111668, originated and developed by the Air Force Cambridge Research Center to speed completion of research projects, are described in a report just released to industry through the Office of Technical Services, U.S. Department of Commerce. Devices for which usual performance is claimed include a cylindrical cam and follower designed to permit smooth operation of sensitive recording devices in both forward and reverse motion; a space-saving printed circuit for transistor power supply; a cable cutting and stripping tool, described as compact and convenient for stripping rubber-covered coaxial cables without injuring the conductors; a small metal slot measuring gauge which allows accurate readings in measuring slots in wave-guides or similar material; specially-formed plastic funnels without ridges on the inside to collect dust; and a quick, accurate and inexpensive method for cutting fine pitch worm gears. Details of construction and operation of these devices are given in this illustrated Second Annual Report of the Air Force Cambridge Research Center dated December 1954. 23 pages, 75¢. Available from OTS U. S. Department of Commerce, Washington 25, D. C.

Electronics Test Equipment Descriptive Data Sheet. This loose-leaf compilation, first released in January 1955, has now been enlarged with the publication of the first major addition and revision totaling approximately 700 pages. Data sheets on over 200 new equipments have been added to the 900 covered in the basic set. Included in this addition is a new index of military nomenclatured equipments, a new cross reference by functional classification and designation, and a new index of commercial test equipment. The compilation is being supplied with a new matching hard-back binder, 10 × 11 ½", marked "Vol. IV." The addition is sold only to holders of the basic set and is priced at $35. The complete four-volume compilation is $135. Further details on request to Carl L. Frederick and Associates, 4630 Montgomery Avenue, Bethesda 14, Md.

The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names. This circular by Kenneth L. Kelly and Deane B. Judd is designed to assist the scientist, businessman, and layman to understand the different color vocabularies used in the many fields of art, science, and industry. The dictionary serves not only as a record of the meanings of the 7,500 individual color names listed, but also enables anyone to translate from one color vocabulary to another. For example the dictionary shows that Grisco-Viridis (biology) equals Serpentine (fashion) which is Mint Green (mass market), or in ordinary language, a light green. The terms by which this dictionary defines color names are those of a refinement of the method of designating colors outlined by the Inter-Society Color Council (ISCC) and developed at the National Bureau of Standards. The system applies not only to the colors of drugs and chemicals, for which it was originally developed, but to the colors of all opaque, clear, cloudy, or fluorescent samples, whether viewed by reflected or transmitted light, and to microscopic structures. 158 pages. $2. Government Printing Office, Washington 25, D. C. Foreign remittances must be in U. S. exchange and should include an additional one-third of the publication price to cover mailing costs.

Electricity in the Home. This paper-bound publication is by Emanvele Stieri and covers the selection, installation, and maintenance of various electrical devices found in modern homes. The opening chapters cover adequate wiring and lighting requirements, batteries and transformers, motors, and repairs and replacements. The remainder of the book deals with fans, air conditioners, electric water heaters, ranges, washers, refrigerators, freezers, etc. 405 pages. $1.75 per copy. Orders should be sent to Barnes and Noble, Inc., 105 Fifth Avenue, New York 3, N. Y.

Instruments and Controls Practices for Recent Single Boiler Turbine Reheat Installations. A report of the Instruments and Controls Subcommittee of the Prime Movers Committee, Edison Electric Institute (EEI). Publication No. 55-21, December 1955. 80¢ to EEI members and their employees; $2 to nonmembers in the USA, and $2.15 to foreign countries. Send orders to: Edison Electric Institute, 420 Lexington Avenue, New York 17, N. Y.

ASTM Reference Radiographs. After four years of zealous effort by hard-working industry members of ASTM Committee E-7 on Non-Destructive Testing, reference radiographs covering types and degrees of discontinuities in steel welds have been approved for publication by the American Society for Testing Materials. The reference radiographs are reproduced from master radiographs taken of official sample weld plates which are the property of ASTM. There are 35 radiographs in the form of transparencies mounted in standard 5- by 8-in. Keysort cards. Details of plate thickness, radiographic method, and welding procedures are given on each card. The transparencies, although reproduced to a density level of approximately 1.0, retain the original radiographic contrast. The reference radiographs are intended to serve as a guide for interpretation. No attempt has been made to establish limits of acceptability for any discontinuity. However, where applicable and upon agreement of all interested parties they may be used in production inspection to evaluate weld soundness as provided for in product specifications. For identification purposes each type of discontinuity is designated by a number. The degree of severity for each defect is indicated by a letter. Provision has been made for expansion of the card file as new reference radiographs become available. $50 per set. Available from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa.

COMPANY FUSES

For example, S&C Drop-Out Power Fuses—Type SMD (marked by arrows, right) are installed at Hialeah substation to protect two 7500 kva 69/13 kv transformers which serve Hialeah Park as well as the hundreds of homes and many small industrial plants which surround it.

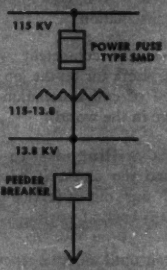
How S&C Power Fuses Are Used in the 69 Kv and 115 Kv System Protection Schemes

The transmission lines of Florida Power & Light Company are tapped at intervals to feed distribution substations. As was originally planned, the power transformers were not always provided with primary protection against secondary faults since primary breakers could not be economically justified.

After a 115 kv power transformer had been lost (for lack of such protection) the matter of protection was reconsidered. It was then decided that this protection was essential and that the device selected must meet these special requirements.

1. Provide system protection over a wide range of fault currents.
2. Coordinate with the transformer damage curve to provide maximum protection to the transformers.
3. Give complete coordination with secondary protective devices over the full range of fault currents.
4. Be capable of withstanding the recovery voltages which might be encountered under various fault conditions.
5. Be low in cost.

S&C Power Fuses, Type SMD, were found to meet all these requirements. Further details of Florida Power & Light's application of these fuses may be found in AIEE Paper No. DP 55-405.



Typical substation tapped directly from Florida Power & Light's transmission lines.

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INDUSTRIAL NOTES ...

Color Television Station Buys RCA Equipment. Purchase of a complete Radio Corporation of America, (RCA) 100-kw vhf television installation by a new color television station in Portland, Ore., has been announced. It involves approximately one million dollars, and represents the largest single installation of RCA equipment for an independently owned color television broadcast station. The new Portland station, which will be completely equipped for origination of color television programs, hopes to be completed before July 1956 when it will utilize the new RCA 100-kw transmitter and an RCA-developed 100-kw superturnstile antenna to achieve 316,000 watts of effective radiated power—the maximum established for high-band vhf television stations by the Federal Communications Commission.

Belgian Private Industry To Install Westinghouse Atomic Power Plant. Belgian private enterprise plans to install an atomic power plant to provide electric energy during the Brussels World's Fair in 1958. Making the announcement in New York was William E. Knox, president of Westinghouse Electric International Company. In Brussels, the announcement was made by H. Robiliart, chairman of the Syndicat d'Etude de l'Energie Nucleaire, an organization of Belgian utilities and manufactures formed recently to develop industrial uses of atomic energy in that country. The 11,500-kw plant will be the first privately financed atomic-electric power plant to go into operation anywhere in the world. It will be built within a few miles of the center of Brussels. Work on the project is already under way in Belgium and the United States. Fuel elements for the unit will be fabricated by Westinghouse from special material furnished by the United States Atomic Energy Commission (AEC) under a separate agreement reached between representatives of the AEC and the Belgium. This agreement was outlined in the Belgian Government's bilateral agreement with the United States Government, signed in 1955.

Kellogg Manufactures Insulated Surgical Instruments. KEL-F (registered trademark) fluorocarbon plastic is being used to coat surgical instruments, making them safer to use in areas where high-frequency, high-voltage electric current is required. If there is a short circuit between instrument and tissue, normal tissue may be burned; coagulation does not occur when desired, and adjacent nerves or nerve roots may be affected by spread of the current. KEL-F trifluorochloroethylene polymer, manufactured by The M. W. Kellogg Company, forms a hard, nonporous film which absorbs no moisture, and resists ordinary wear. Coated instruments now in use have been autoclaved over 100 times and the coating still shows no tendency to chip or peel and continues to retain all its insulating qualities. The coating is flexible enough to allow any reasonable alteration in instrument shape and it can be applied to almost any irregularly contoured surface.

Bendix-Pacific Consolidates Engineering and Development Operations. The Pacific Division of Bendix Aviation Corporation has announced the approaching completion of a large addition to the engineering building on Sherman Way in North Hollywood, Calif. The purpose of the new building is for the centralizing and consolidating of all engineering activities formerly housed at three separate locations in the San Fernando Valley, Calif. It will include the latest in test and development equipment, and is part of Bendix-Pacific's long-range plan which ties into the nation's weapons systems concept.

New Helicopter Uses Yardney Silvercel. Results achieved with a Yardney Silvercel aircraft battery in a series of rigid tests have resulted in the adoption of the Silvercel as original equipment on the new Sikorsky *S-59* gas turbine helicopter, it was announced by Yardney Electric Corporation, 44 Leonard Street, New York, N. Y. The Yardney Silvercel battery, weighing 26 pounds, with a capacity of 40-amp hours, and a nominal 24-volt rating, under identical conditions, was used more than 18 months in the *XH-39* military version of the *S-59* without any maintenance or servicing and has started the engine more than 300 times without failure. The reduction in weight, as well as the high efficiency of the Silvercel, has made it a most desirable feature of the new *S-59*.

Generating Station To Expand. Directors of the Puget Sound Power and Light Company, Seattle, Wash., approved plans to enlarge the Snoqualmie Falls hydroelectric generating station from 22,000 to 42,000 kw. The project, scheduled for completion in April 1957, will cost about $3 million, and includes rebuilding the existing substation at the site. It will make additional power available for the area's expanding economy, and is another forward step by Puget as a part of the Puget Sound Utilities Council Program to provide an adequate power supply for the region.

General Electric Notes. A realignment of the General Electric Company's organization with a principal aim of better meeting the needs of an industrial electronics business, which is expected to double in size in the next five years, has been announced. Increases in the use of computers, automation, and semiconductors are the major factors in the anticipated increase in electronics by 1960. Six company components operating in the field of producers' and

(*Continued on page 20A*)

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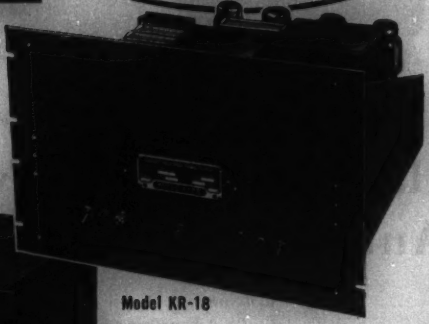
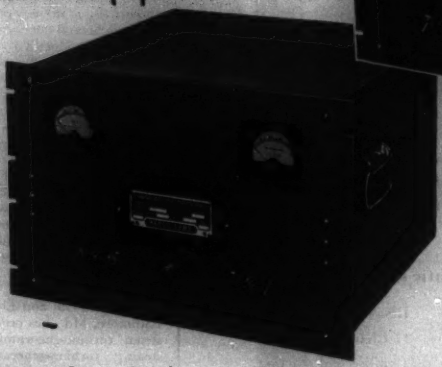


Model KR-18



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REGULATION: Less than 0.2 volts for line fluctuation from 105-125 volts and less than 0.2 volts for load variation from 0 to maximum current.

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To include 3" Current and Voltage Meters, Add M to Model number (e.g. KR 16-M) and Add $30.00 to the Price.
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KR17	100-200	has two	19"	12¼"	17"	$625
KR18	195-325	15 Amp.	19"	12¼"	17"	$695
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Industrial Notes

(Continued from page 18A)

military electronics were assigned to the General Electric Electronics Division. In addition, an industrial electronics laboratory, an industrial computer section, and an electronics business study were established in the division.

The Electronics Division manufactures light and heavy military electronic equipment; electronic components; electronic tubes; semiconductor products, transistors and rectifiers; broadcast radio and television transmitters, antennas, and studio equipment; closed-circuit television equipment; and microwave relay and two-way radio transmitters and receivers. The changes announced also involved the regrouping of all of General Electric's major consumer product activities into a Consumer Products Group, formerly the Appliance and Electronics Group. The group includes five divisions, among them the Applicance and Television Receiver Division, formerly the Major Appliance Division, and the Housewares and Radio Receiver Division, formerly the Small Appliance Division. New departments have been established in each of those divisions to carry on General Electric's home radio and television businesses. The Consumer Products Group also includes the company's Air Conditioning Division, Hotpoint Company Division, and Lamp Division. The Industrial Components and Lamp Group, now becomes the Industrial Components and Materials Group.

A permanent building designed to house giant electronic computers has been completed at the General Electric Company's jet engine plant near Cincinnati, Ohio. Two *704* computers, newly-designed equipment made by the International Business Machines Company, will be installed in the building. The computers will be used to make high-speed calculations in jet engine design work.

Baltimore Gas and Electric Company of Baltimore, Md., has ordered a 125,000 kw steam turbine-generator from the large steam turbine-generator department. When installed at the Herbert A. Wagner station in greater Baltimore, the steam turbine-generator will furnish the average yearly electricity needs for more than 206,000 persons. The turbine for the 160,000-kv ampere generator will be of the 3,600-rpm tandem compound, double-flow, reheat type.

Raytheon Enters The Atomic Energy Field. The entry of Raytheon Manufacturing Company into the atomic energy field has been announced with the publication of its pamphlet, "Nuclear Reactor Data." The booklet lists significant data on nuclear reactors throughout the world, including six in Russia. This information represents the most complete work of its type and is being furnished to key leaders in industry, Government, and education as a public service by the Waltham, Mass., electronics firm. Additional copies will be available to other interested persons at a nominal charge. The study which resulted in the data booklet was carried out

(Continued on page 26A)

CONTINUITY

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Only ASCO Automatic Transfer Switches satisfy all these essentials in addition to the nominal requirements of transfer switches. For this convincing reason, many engineers are today specifying ASCO — *the one source for a full line of absolutely dependable automatic transfer switches.*

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Two of several bleed steam valves that control the flow of steam from turbines to the main condensers.

Power source for the operation of instruments on the control panel must not fail. Several ASCO units are used here.

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Inspector checks the oil level in the auxiliary lubricant pump for the generators.

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MODEL S-14-A

DC COUPLED
10 mv/inch
½ CYCLE SWEEP

Size: 12" x 6" x 7"
12¾ Pounds

ANOTHER EXAMPLE OF Waterman PIONEERING...

The HIGH GAIN POCKETSCOPE, model S-14-A, is an outstanding achievement in the field of oscilloscopes. The high vertical and horizontal sensitivities of 10 and 15 millivolts rms/inch respectively; frequency responses within —2 db from DC to 200 KC; non-frequency discriminating attenuators and gain controls; plus individual calibration voltages are but a few of the heretofore unobtainable characteristics of DC coupled oscilloscopes. The sweep is operated in either a repetitive or trigger mode over a range from 0.5 cycles to beyond 50 KC with synchronization polarity optional. All this and portability too! The incredibly small size and light weight of the S-14-A now permits "on-the-spot" use of the oscilloscope in all industrial, medical, and electronic fields. Its rugged construction assures "laboratory performance" regardless of environment.

WATERMAN PRODUCTS CO., INC.
PHILADELPHIA 25, PA.
CABLE ADDRESS: POKETSCOPE

WATERMAN PRODUCTS INCLUDE

S-4-C SAR PULSESCOPE®
S-5-C LAB PULSESCOPE
S-11-A INDUSTRIAL POCKETSCOPE®
S-12-B JANized RAKSCOPE®
S-14-A HIGH GAIN POCKETSCOPE
S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
RAYONIC® Cathode Ray Tubes
and Other Associated Equipment

MEMO Write for details today!

WATERMAN PRODUCTS

Industrial Notes

(*Continued from page 20A*)

under the direction of William A. Robba, head of the firm's nuclear power group in the Research Division. Material was gathered from a wide variety of sources, including scientific journals and other published works in many languages. The entire project was aided greatly by the declassification of significant quantities of information for the Geneva Conference.

Electron Products Moves. Electron Products, Inc., a subsidiary of Preco, Inc., manufacturers of custom-built miniaturized capacitors, and radio noise filters, moved to Pasadena, Calif., on December 15, 1955. Mr. I. Berry will continue as general manager of this operation. The plant is located at 430 North Halstead Street in Pasadena's "Instrument Park."

New Plant. ElectroData Corporation has dedicated its new, half-million-dollar plant in Pasadena's (Calif.) Hastings Ranch district. The modern California-style structure is the first of two such facilities completed to manufacture high-speed electronic computers.

NEW PRODUCTS

New Electric Brake Requires Little Maintenance. Star-Kimble Motor Division, Miehle Printing Press and Manufacturing Company, Bloomfield, N. J., has developed an electric brake that offers greater freedom from adjustments and maintenance. Designated series *E*, the device features a magnet with a circumferentially wound core and armature which reduces power losses by 80 per cent. Preformed coils inserted in slots milled in the core are the equivalent of 6 *E* magnets and, because of this number, is divisible by 2

(*Continued on page 28A*)

For more information circle 21 on reader service card.

DOW CORNING CORPORATION

Silicone Dielectrics

ELECTRICAL AND ELECTRONIC NEWS No. 3

New Silicone-Glass Insulators Meet Class H Specifications Are Stronger, Easier to Use

Production methods developed by Silicone Insulation, Inc., New York City, reduce the cost of molding one-piece silicone-glass laminated coil bobbins and other Class H components. Users save assembly costs.

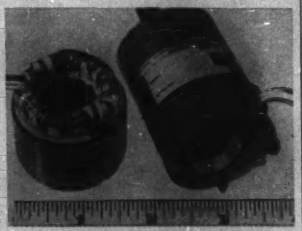
In the bobbins, glass cloth impregnated with Dow Corning 2104 silicone resin flares out from the cores into flanges providing completely unified structures that are easy to handle for quick assembly, and exceptionally strong in proportion to their wall thickness. Tolerances may be held as low as ± .001".

These one-piece laminated bobbins are serviceable at Class H temperatures; show no tendency to break at the joints, crumble or delaminate. Already in use by several

leading manufacturers of high temperature transformers, relays, solenoids and controls, they are available in a wide range of sizes and dimensions, and may have as many as six integral flanges.

Price-wise, silicone-glass laminated bobbins compare favorably with conventional Class H assemblies. Low mold costs permit production runs of as few as one hundred parts. *No. 12*

New 1956 Reference Guide to Dow Corning silicone products briefly reviews properties and applications of the silicone fluids, compounds, greases, resins and rubbers that are most commonly used. Indexed by application, this new 12-page reference guide includes basic information on liquid dielectrics, dielectric compounds, electrical insulating resins and varnishes, Silastic and Class H components. *No. 13*



Silicone Insulation Adds Life, Cuts Size Of Miniature Motor in B-52A Bomber

PROBLEM:

Ambient temperatures range from —65 to 300 F.

Size and weight must be held to a minimum.

Maximum reliability is imperative.

To meet those requirements, design a miniature a-c motor for continuous duty in the oil temperature controller for the Boeing B-52A Stratofortress.

SOLUTION:

Design engineers with the AiResearch Manufacturing Division of The Garret Corporation found the best solution to that problem in electrical insulating materials and high temperature paints made with Dow Corning silicone. Dow Corning 33 Grease solved the bearing problem.

A silicone bonded asbestos-glass laminate, made by the Irvington Varnish and Insulator Company is used for slot and phase insulation. Dow Corning Sylkyd enameled magnet wire, manufactured by Hi-Temp Wires, Inc. is used in the windings. Silicone-glass laminate is used for end laminations and slot wedges. End connections are tied with Silastic*-impregnated glass cord.

Silastic-impregnated Turbo 117 glass sleeving, made by William Brand and Company, is used to insulate the connections because of its flexibility and outstanding resistance to fraying.

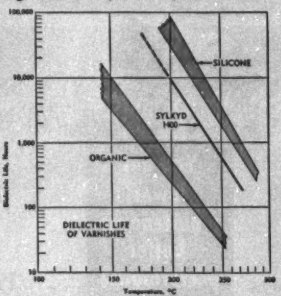
The stator is impregnated with Dow Corning 997 silicone varnish and baked at 400 F. The stator bore is painted with Sicon black silicone enamel, manufactured by Midland Industrial Finishes.

The ball bearings are lubricated with Dow Corning 33 silicone grease to give long service at temperatures ranging from —65 to 300 F. *No. 14*

New Silicone Varnish Improves Performance of Class B Machines

Sylkyd* 1400, a new modified silicone dipping and impregnating varnish, makes possible the production of more durable, more reliable Class B electrical equipment. Highly resistant to heat, it also has excellent bond strength and outstanding resistance to moisture, oil and degreasing solvents.

Accelerated life testing in our motor test laboratory indicates that the insulating life expectancy of Sylkyd 1400 at a hottest spot temperature of 130 C is 25 to 50 times that of Class B varnishes. As shown in the graph, the dielectric life of this new varnish approaches that of straight silicone (Class H) varnishes.



Sylkyd 1400 appears to be particularly useful on railroad traction motors and other heavy duty equipment subject to heavy overloads and periodic cleaning. Costwise, it is less expensive than Class B varnishes when the extra life and reliability are taken into consideration. *No. 15*

*T.M. REG. U.S. PAT. OFF.

Send Coupon for More Information

DOW CORNING CORPORATION - Dept. 4102
Midland, Michigan

Please send me 12 13 14 15

NAME _____

TITLE _____

COMPANY _____

STREET _____

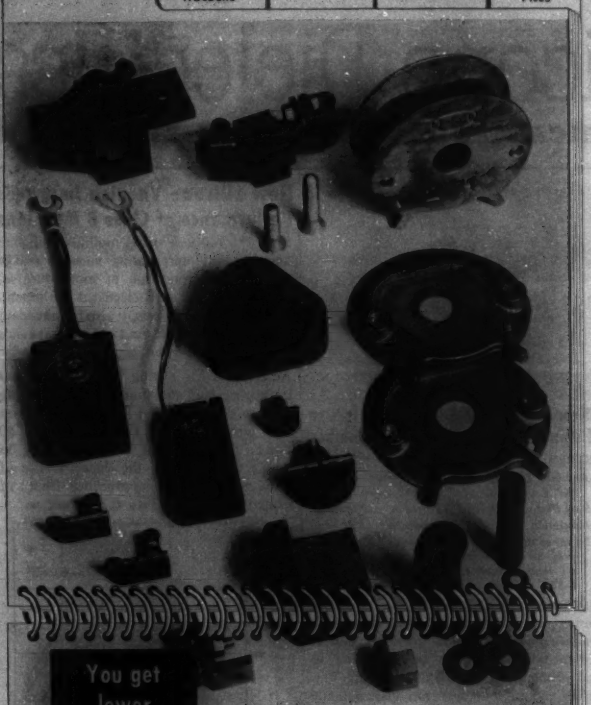
CITY _____ ZONE ____ STATE _____

ATLANTA • CHICAGO • CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEW YORK • WASHINGTON, D. C. (Silver Spring, Md.)

Canada: Dow Corning Silicones Ltd., Toronto; **Great Britain:** Midland Silicones Ltd., London; **France:** St. Gobain, Paris

For more information circle 22 on reader service card.

INTRODUCTION | BRUSHES AND HOLDERS | CONTACTS | CURRENT COLLECTORS | VOLTAGE REGULATOR PILES



You get lower maintenance — better performance ...with MORGANITE

Above are just a few Morganite products designed to help the Electrical Engineer gain better performance, lower maintenance from his electrical equipment. Carbon, which is self-lubricating, resistant to burning and free from welding, is particularly suitable as an electrical contact material.

Carbon products have been our business for 50 years. Through constant research we have learned the peculiar traits and properties of various grades and qualities of carbon. This experience places us in a position to supply you with just the right grade and design for your particular needs.

Our engineers will be glad to discuss your electrical problems with you.

50th ANNIVERSARY 1906 · 1956

Morganite INCORPORATED

Manufacturers of fine carbon-graphite products for fifty years.
3308 48th Avenue, Long Island City 1, New York

New Products

(*Continued from page 26A*)

or 3; the brake may be connected to either 2- or 3-phase motors with equal facility. Another advantage is high pull-in force at large air gaps important in electric brakes because brake-lining wear causes the armature to recede from the pole faces and, in the case of a lining that has been almost worn away, may displace the armature so far that the magnet cannot attract it against the force of the brake springs. The manual release in the series *E* is located off-center to permit two-end shaft mounting. By an arrangement of two release pins a limit stop for the magnet armature is provided; the pins keep the armature from being displaced so far that the magnet cannot pick it up.

Item 1 on the card.

Transistor Wrist Radio. A new broadcast band all-transistor wrist radio has been developed by LEL, Inc., Copiague, N. Y., a division of Linear Equipment Laboratories, Inc. A special (patent pending) rf reflex circuit is incorporated which allows good selectivity and sensitivity. No antenna is required in moderate signal

strength areas. Its small size ($2^1/_4$ inches long, $1^3/_4$ inches wide, 3/4 inch thick), and weight (2.5 ounces with batteries), make it ideal for wearing on the wrist or shirt pocket. Three transistors are used, allowing for economy of operation from five button size mercury cells which last up to 100 hours. The unit features a two-stage transformer coupled audio amplifier and a no whistle regenerative circuit. A hearing aid receiver allows for private listening. Printed circuitry is used throughout. Band coverage is 550 to 1,600 kc. Sensitivity 200μv per meter. Output 2–2.5 milliwatts.

Item 2 on the card.

Uhf Super-Power Tube for Television. A super-power beam power tube which can deliver a synchronizing-level power output of 25 to 30 kw when used as a grid-driven power amplifier in color or black-and-white television service, has been developed by Radio Corporation of America (RCA). The tube, RCA-*6806*, may also be used as a continuous-wave amplifier in class *C* telegraphy service to provide a useful power

(*Continued on page 32A*)

For more information circle 23 on reader service card.

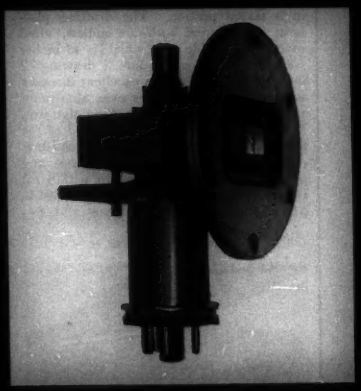
the "Long Haul"

THAT COUNTS!

you advantages like these:

- 160% greater maximum hop distance
- Fewer microwave relay stations
- 10,000 watts effective radiated power—50% smaller antennas
- Reduced tower installation costs
- 10 db additional signal safety margin

Vol. 75
1956



Philco CLR-Z Microwave is greater ... rugged ... compact ... reliable! Built to provide continuous, trouble-free service over years of long haul ...

Philco Microwave Systems provide ... high-fidelity ... efficient power ... operation ... on the principle of ... Philco CLR-Z Microwave Radio ...

PHILCO CORPORATION

Government and Industrial Division

Philadelphia 44, Pennsylvania

In Canada: Philco Corporation of Canada, Ltd., Don Mills, Ontario ... Philco International Corp., Export

Standard
TRADE MARK
transformers

built SPECIALLY for the *original equipment manufacturer

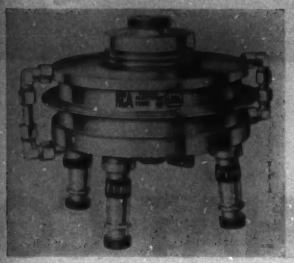
Each component part of **your** equipment must function without failure. One of the most important of these integral parts is the transformer. Standard O.E.M. Transformers are noted for their accuracy, dependability, compactness and sound basic construction. They're engineered especially for O.E.M. use. Many well-known original equipment manufacturers have specified O.E.M. Transformers for over 30 years. You can have Standard O.E.M. Transformers tagged for you, too! Consult your nearby Standard representative or write to Standard direct for specific information, literature or engineering consultation.

Standard
THE STANDARD TRANSFORMER COMPANY
WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

For more information circle 26 on reader service card.

New Products

(*Continued from page 28A*)

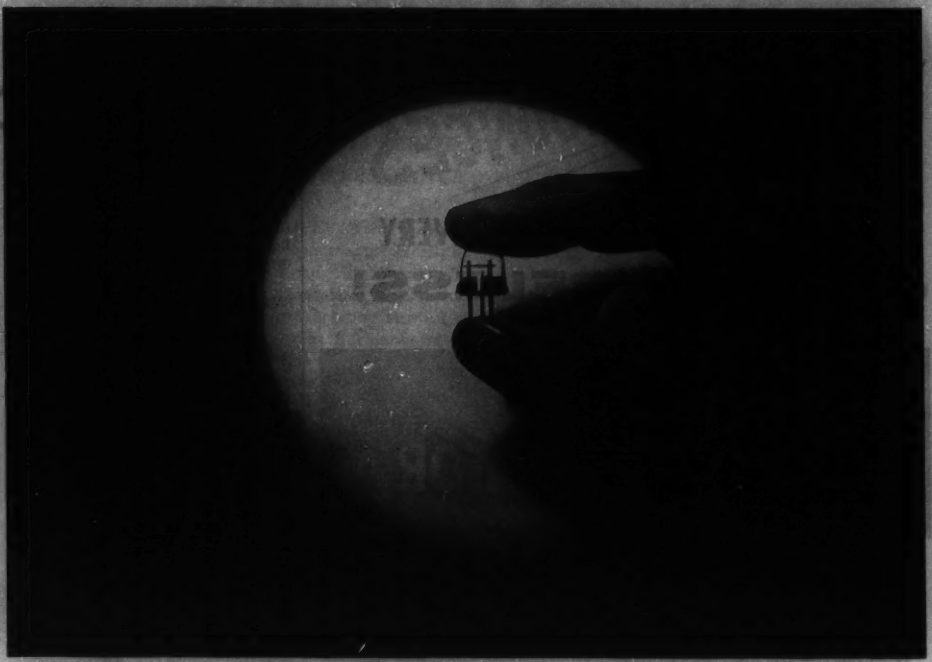


output of 25 kw at 400 mc. In single-sideband service, it will provide a maximum-signal power output of 15 kw at 550 mc. The new tube design features a coaxial-electrode structure in which the centrally located plate is surrounded by a symmetrical array of unit electron-optical systems. These systems embody a structural design which permits not only close spacing, but also accurate alignment of the electrodes. Other features of the *6806* include low inductance, large area, radio-frequency electrode terminals insulated from each other by low-loss ceramic bushings, relatively low output capacitance, very low feedback capacitance, multi-strand thoriated-tungsten filament for economical operation, high emission capability, and long life.

Item 3 on the card.

The Draft-A-Matic. A new drafting desk, by The General Fireproofing Company, Youngstown, Ohio, makes possible the performance of all drafting operations in a seated postion. The drafting platform is equipped with an endless, vinyl plastic belt. The belt, which is 48 inches wide and can accommodate a drawing 72 inches long, provides an excellent drawing surface. The belt moves over aluminum rollers at each end of the drafting platform. By turning the wheel at either end of the front roller, the draftsman moves the belt and the drawing affixed to it so that any part of the drawing is brought within his range of visibility and reach. Draft-A-Matic sharply reduces fatigue and fre-

(*Continued on page 38A*)



Experimental model of Bell's new high-frequency transistor. It has a cut-off frequency of at least 500 mc and can be used to amplify 2500 independent voices simultaneously.

THE TRANSISTOR
that smashed a frequency barrier

A new transistor invented at Bell Telephone Laboratories can provide broadband, high-frequency amplification never before possible with transistors. The big leap in frequency is made possible by a diffusion process that earlier enabled Laboratories scientists to create the Bell Solar Battery.

This transistor is a 3-layer semiconductor "sandwich." High-frequency operation is obtained by making the central layer exceedingly thin. This was difficult to do economically by any known method.

The new diffusion process, however, easily produces microscopic layers of controllable thickness. Thus it opens the way to the broad application of high-frequency transistors for use in telephony, FM, TV, guided missiles, electronic brains and computers.

The new transistor shows once again how Bell Laboratories creates significant advances and then develops them into ever more useful tools for telephony and the nation.

A Bell scientist checks temperature as arsenic vapor diffuses into germanium, creating 4/100,000-in. layer.

BELL TELEPHONE LABORATORIES

IMPROVING AMERICA'S TELEPHONE SERVICE PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS

For more information circle 30 on reader service card.

IMMEDIATE DELIVERY

on a NEW TUBELESS!

MAGNETIC AMPLIFIER

AC LINE VOLTAGE REGULATOR

MODEL MLR - 1000

1 KVA

- ☆ NO TUBES TO REPLACE
- ☆ NO MOVING PARTS
- ☆ NO VIBRATING CONTACTS
- ☆ REGULATES RMS VALUE
- ☆ IDEAL FOR UNATTENDED INSTALLATIONS

Specifications...

- Input Voltage Range: 95 to 135 volts
- Output Voltage: Nominal 115 volts. can be adjusted from 110 to 120 volts.
- Output Current: 8.5 amperes
- Regulation Accuracy: ±0.25% for any combination of line or load
- Frequency Range: 60 cycles ±10%
- Wave Form Distortion: 3% maximum
- Power Factor Range: 0.5 lagging to 0.9 leading
- Response Time: 0.2 sec.
- Maximum Load: 1.0 KVA
- Ambient Temperature Range: Up to 45° C.
- Dimensions: 19½" wide x 11" high x 11½" deep (cabinet) 19" wide x 10½" high x 11½" deep (rack panel)
- Mounting: Cabinet or 19" Rack Panel
- Finish: Gray Hammertone
- Weight: 85 lbs.

PERKIN power supplies

WIRE COLLECT TODAY for PRICE QUOTATIONS!

Write for Bulletin MLR 1000

PERKIN ENGINEERING CORP.

345 KANSAS ST. EL SEGUNDO CALIF. PHONE OREGON 8-7215

New Products

(*Continued from page 32A*)

quent time-outs. The advantages of posture chairs now can be enjoyed in the drafting room.

Item 4 on the card.

Drill Point Gauge. Swanson Manufacturing Company, 1236 Sherman Avenue, Evanston, Ill., has developed an ingenious tool called the Swanson 4-Way Drill Point Gauge which enables anyone to measure the chisel point, point angle, and

clearance angle in a matter of seconds. The gauge also includes a point center scale. Made of stainless steel, the drill point gauge is in the form of two semicircular discs held together at the center by a pivot. The bottom disc is 4 inches in diameter, and contains 1 degree calibrations along the rim for measuring any chisel point angles from 110° to 135°; any point angle from 40° to 90°; and any clearance angle from 0° to 20°.

Item 5 on the card.

Plug-In Strip. A new line of plug-in strip, equipped with an integral raceway to handle branch circuit conductors, in addition to its standard use in providing electric outlets, has been announced by the National Electric Products Corporation, Pittsburgh, Pa. Designed as type *CF-4* plug-in strip, the new line was developed in answer to contractors' requests for a method of running branch circuits, 110- and 220-volt service, in the same duct that carries the plug-in strip harness. These provisions make possible a normal plug-in strip installation while providing the capacity to handle additional single-phase or 3-phase load within the limits of the number *10* conductors, in accordance with the Electrical Code. Underwriters' Laboratories have granted approval for installing up to three number *10* type *TW* electric conductors in the raceway space located

(*Continued on page 40A*)

For more information circle 31 on reader service card.

ROEBLING PAPER POWER CABLE WITH TELLURIUM LEAD ALLOY SHEATH

TELLURIUM LEAD ALLOY SHEATHS MEET ALL REQUIREMENTS FOR FATIGUE RESISTANCE

TODAY'S HIGHER TEMPERATURES and increased loads are power cable problems met most satisfactorily and economically by Roebling Tellurium Lead Alloy Sheath. This sheath has absolutely top fatigue resistance; gives vastly increased service life despite severe bending stresses and cable movement during load cycles. Furthermore, Roebling Tellurium Lead Alloy has outstanding stability under heat—high temperature incurred at joints, terminations and in duct splicing cause no grain growth or physical impairment.

Roebling is unmatched in the breadth of its experience with Tellurium Lead Alloy Sheath and in the volume of cable it has produced with this remarkable sheathing. We will welcome the opportunity to send you Bulletin 205-B containing technical data on Roebling Tellurium Alloy Sheaths.

Lead strip fatigue test

Fatigue test of full cable sections—temperature-controlled

ROEBLING

Subsidiary of The Colorado Fuel and Iron Corporation

JOHN A. ROEBLING'S SONS CORPORATION, TRENTON 2, N. J. BRANCHES: ATLANTA, 934 AVON AVE. • BOSTON, 11-15 STILLINGS ST. • CHICAGO, 6523 W. ROOSEVELT RD. • CINCINNATI, 3253 FREDONIA AVE. • CLEVELAND, 19325 LAKEWOOD HEIGHTS BLVD. • DENVER, 4801 JACKSON ST. • DETROIT, 915 FISHER BLDG. • HOUSTON, 6216 NAVIGATION BLVD. • LOS ANGELES, 5340 E. HARBOR ST. • NEW YORK, 19 RECTOR ST. • ODESSA, TEXAS, 1920 E. 2ND ST. • PHILADELPHIA, 230 VINE ST. • PITTSBURGH, 1723 HENRY W. OLIVER BLDG. • SAN FRANCISCO, 1740 17TH ST. • SEATTLE, 900 1ST AVE. S. • TULSA, 321 N. CHEYENNE ST. • EXPORT SALES OFFICE, 19 RECTOR ST., NEW YORK 6, N. Y.

For more information circle 32 on reader service card.

CARBON SOLVES DESIGN, ENGINEERING, AND PRODUCTION PROBLEMS

Light weight, corrosion-proof CARBON PUMP VANES

Vanes of Stackpole carbon-graphite for automotive rotating pumps are low in cost, light in weight and are made to close tolerances. Thanks to their chemical inertness, self-lubricating qualities and other factors, they are ideally suited for pumping air, corrosive chemicals or gases.

OIL SEALS that minimize pitting and blistering

Molded from carbon and graphite sometimes balanced with resins or metal powders to meet specific operating requirements, Stackpole seal rings are available in grades, types and sizes for almost any need. Recently developed grades greatly minimize pitting and blistering.

CARBON RODS for salt bath rectification

Stackpole rods are highly effective in avoiding decarburization of metal in heat treating by electric salt baths. Furnace electrode life is increased 4 to 6 times. Sludge formation and salt "drag out" are minimized. Greater fluidity of bath assures much faster, completely uniform heating.

THIS IS OUR 50 Year STACKPOLE

STACKPOLE CARBON COMPANY
St. Marys, Pa.

STACKPOLE

Quality Products—backed by the keen personal interest and cooperation of the specialists who engineer them

(*Continued from page 38A*)

beneath the standard plug-in strip assembly. A 3/4-inch knockout at each end of a 6-foot strip allows in-and-out accessibility of additional branch circuit wires without special feed fittings.

Item 6 on the card.

Magnetic Information Storage Drum. Development of a new magnetic information storage drum, model *ERA 1114*, has been announced by the St. Paul Laboratory, Remington Rand Univac Division, Sperry Rand Corporation, 1902 West Minnehaha Avenue, St. Paul, Minn. This drum, the sixth in the Univac standard line, has a capacity of 42,000 binary digits (bits of information) and a nominal speed of 3,550 rpm. Magnetic drums are designed for storage of information with computer elements such as digitizers, punched cards or tapes, magnetic tapes, electric typewriters, high-speed printers, and graphic display platters. Univac *ERA 1114* drums have noncontact recording and playback, alterable yet nonvolatile storage, random access, and uniform long-life performance. Information on over 20 information tracks are stored by

means of magnetized spots or binary digits. It has a vertically mounted, integral drive motor, and is constructed to withstand extreme environmental condi-

(*Continued on page 44A*)

For more information circle 33 on reader service card.

Tension Control Problems?

Dynamatic's Long Experience in Solving Industrial Windup and Unwind Problems will be Valuable to You

DYNAMATIC®

Metal slitter powered by Dynamatic Drives. Adjustable speed liquid cooled coupling used as main drive; Ajusta-Spede® Drives, with constant tension control, wind up the metal strips.

Completely Dynamatic driven paper super-calender. Adjustable speed liquid cooled couplings with Eddy-Current brakes drive the calender rolls and center rewinder. Dynamatic liquid cooled brake provides center unwind hold-back. Co-ordinated controls provide for wide-range adjustment of speed and tension.

Dynamatic Eddy-Current Drives with tension controls are used extensively in the fields of paper, rubber, textiles, ferrous and non-ferrous metals, plastics, and printing.

Combined with associated controls, Dynamatic Eddy-Current Drives provide automatic constant tension as the roll diameter changes on center rewinds and unwinds. Constant tension is maintained over a wide range of material delivery speeds without the use of dancer or follower rolls. Controls may be adjusted for tapered tension to increase or decrease tension automatically as the roll changes diameter.

Multi-range tension or tension adjustment over a wide range is easily accomplished at the operator's station to accommodate materials of various thicknesses or widths. Control modifications are available to provide for inertia compensation and other individual requirements. Dynamatic engineers are available for consultation on your problems.

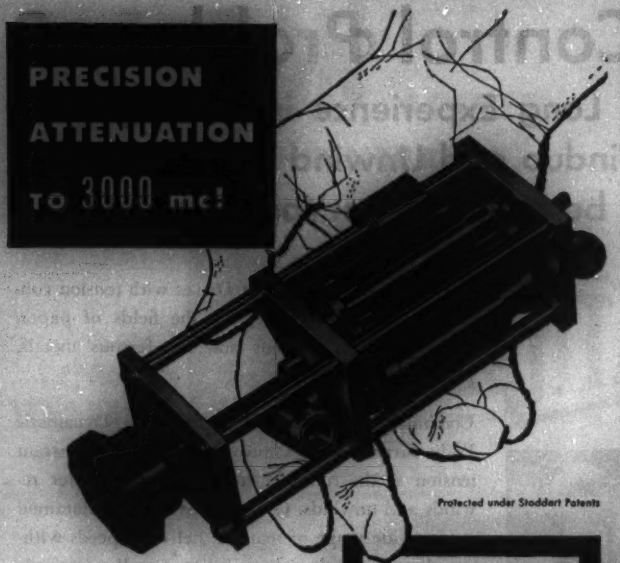
Bulletins giving detailed information on Dynamatic Tension Control will be sent free at your request.

EATON

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE · KENOSHA, WISCONSIN

For more information circle 36 on reader service card.



six-position
TURRET ATTENUATOR
featuring **PULL-TURN-PUSH** *action*

FREQUENCY RANGE: dc to 3000 mc.
CHARACTERISTIC IMPEDANCE: 50 ohms.
CONNECTORS: Type "N" Coaxial female fittings each end.
AVAILABLE ATTENUATION: Any value from 1 db to 60 db.
VSWR: 1.2 max., dc to 3000 mc/s, values from 10 to 60 db. As value decreases below 10 db, VSWR increases to not over 1.5.
ACCURACY: ± 0.5 db.
POWER RATING: One watt sine wave power dissipation.

SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATIONS

This new group of pads and terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles. For example, the two connector types, either male or female, can be mounted on the same attenuator pad, with or without flanges, so that it may serve as an adapter as well as an attenuator. Frequency range, impedance, attenuation, VSWR, accuracy and power rating are as designated above. Send for free bulletin entitled "Measurement of RF Attenuation."

STODDART aircraft radio co., inc.
6644 E. SANTA MONICA BLVD., HOLLYWOOD 38, CALIFORNIA HOLLYWOOD 4-9294

For more information circle 37 on reader service card.

New Products

(*Continued from page 40A*)

tions. Detailed information and complete specifications on the new Magnetic Storage drum model *ERA 1714* and other units manufactured by the firm are available.

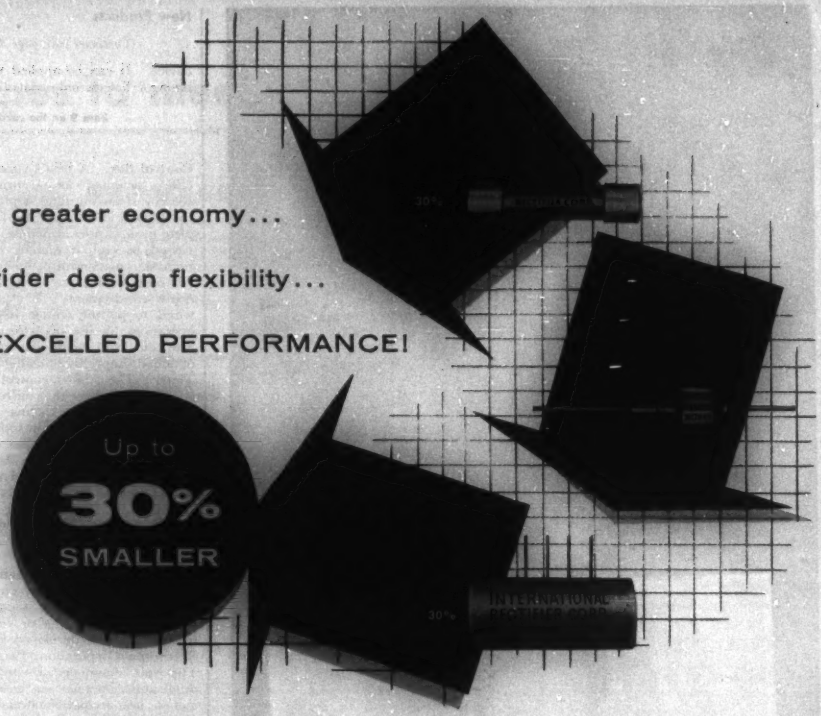
Item 7 on the card.

Visual Monitor. Century Electronics and Instruments model *20* visual monitor combines 24 moving-spot, light-beam galvanometers in one package, 7 by 5 by 6¾ inches, weighing less than 13.5 pounds, to permit simultaneous graphic display of 24 separate electrical signals on a single 3- by 4-inch ground glass screen. The model *20* monitor represents the ideal way to view the outputs of a series of thermocouples, pressure transducers, strain gauges, or other similar signal sources. Use of low-period galvanometers and a long-path optical system permits presentation of electrical signals up to 42 cycles per second with only 80 microamperes required for full-scale deflection. Spot intensity is sufficient to permit photography in photo panel displays or for viewing under conditions of high incident light. The model *20* visual monitor is self-contained, and may be shockmounted for use where extreme conditions of shock and vibration are encountered. For operation from 22–28 volts a-c/d-c at 1.5 amperes. Write for Century Catalogue *CGC-309*. Century Electronics and Instruments, Inc., Tulsa, Okla.

Item 8 on the card.

Electronic Scales Make Weights Records Remotely. A new digital-scanning electronic unit has been announced by Toledo Scale Company that transmits weights to the user's remotely located tabulating card punches, adding machines, and other data handling devices. A Toledo Scale Company development achieves a long-sought goal by bridging electronically the gap between the indication of a weight by the rotary movement of an indicator on a graduated dial, and the recording or indicating of this weight automatically in digital or numerical form at any remote location. The achievement in the field of weighing is comparable to breaking through the sound barrier in aviation. It means that weight data is no longer limited either to close proximity to the point of origin, or limited in the type of indication or recording. Weights can now go anywhere and be reproduced accurately in almost any form—tabulated, added, recorded, or indicated in digital form. Equally important, it is said, the digital conversion is achieved with maintenance of the normal accuracy of the original, without the electrical drift, nonlinearity, and friction errors that were barriers to earlier efforts. The basic element consists of a motor-driven light source that scans the lines exposed on a special chart. The output is a series of electrical pulses that pass through an electronic counter and translator to the remote recording or indicating

(*Continued on page 46A*)



Miniaturized Hi-Voltage

QUALITY CARTRIDGE RECTIFIERS BY

International

Manufactured under the United States Army Signal Corps Reduced Inspection Quality Assurance Program
RIQAP

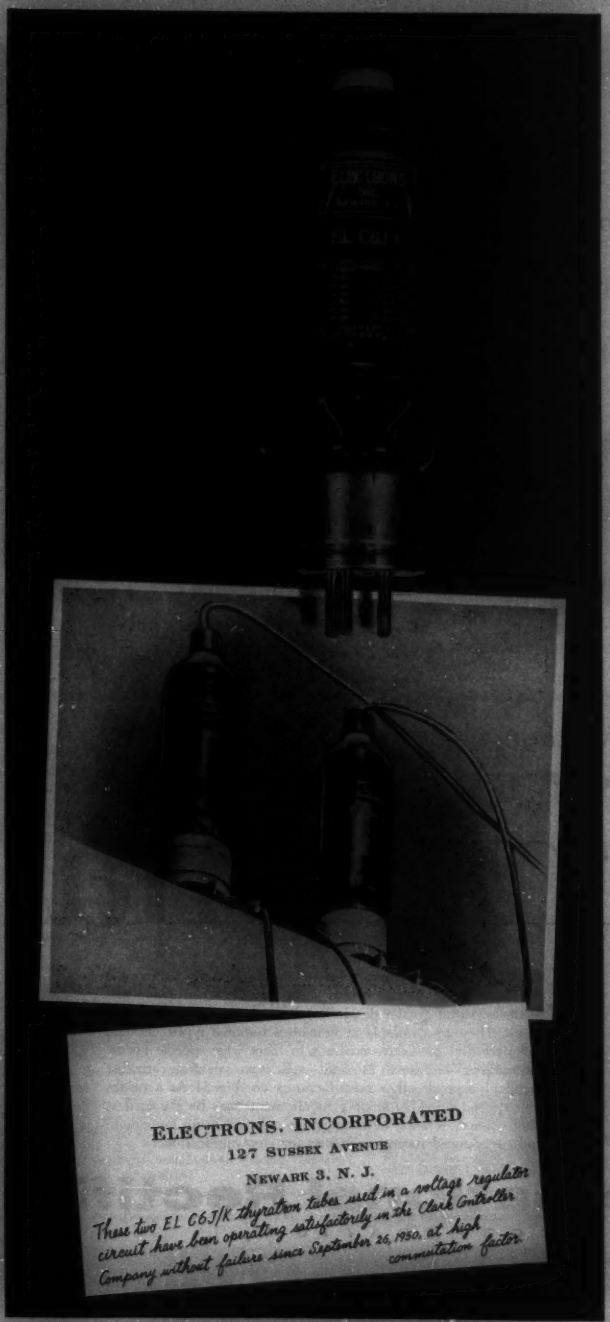
A WORLD OF DIFFERENCE THROUGH RESEARCH

The higher voltage ratings of International selenium rectifier cells result in a 30% shorter length cartridge! These miniature-size rectifiers permit greater design freedom where space is at a premium. They are available in numerous terminal types, circuits, cell sizes and protective coatings to meet your specific needs. International—leader in the field—sells more selenium cartridge rectifiers than all other manufacturers combined! As a result, your special cartridge rectifier requirements may be standard at International. A wire, letter or phone call will bring immediate and experienced recommendations for your application.

International Rectifier
CORPORATION

EXECUTIVE OFFICES: 1521 E. GRAND AVENUE, EL SEGUNDO, CALIFORNIA • PHONE OREGON 8-6281
NEW YORK: 501 MADISON AVE., PLAZA 3-4942 • CHICAGO: 205 W. WACKER DR., FRANKLIN 2-3689
IN CANADA: ATLAS RADIO CORP., LTD., 50 WINGOLD AVE. W., TORONTO, ONTARIO. RU 1-9174

WORLD'S LARGEST SUPPLIER OF INDUSTRIAL METALLIC RECTIFIERS


ELECTRONS, INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.
These two EL 6GJ/K thyratron tubes used in a voltage regulator circuit have been operating satisfactorily in the Clark Controller Company without failure since September 26, 1950, at high commutation factor.

New Products

(*Continued from page 44A*)

device. It can be applied to the current types of Toledo industrial dial scales.

Item 9 on the card.

Control Box. A new Lynco control box, *CB-1*, designed for accurate electronic control of any drilling depths desired for the Lynmatic *101* drill head on one complete cycle is now available. The *CB-1* is valved in such a manner as to permit simultaneous control of up to 4 Lynmatic *101* units, even those having different hole depth requirements. The control box is wired to permit remote inauguration of operations by the operator, machine, by cam, etc., and continuous cycling can be obtained simply by plugging in the Lynco Timer. The *CB-1* control box works equally well where the control of sequence operations of single acting air cylinders becomes advantageous in tooling and production. The control box is manufactured by Lynco, Inc., Los Angeles, Calif., and distributed by Burklyn Company, 3429 Glendale Boulevard, Los Angeles.

Item 10 on the card.

High-Speed Tape Duplicator. A high-speed tape duplicator which copies both single- and dual-track tapes previously recorded at $3^3/_4$, $7^1/_2$, or 15 inches per second has been developed by the Presto Recording Corporation, Paramus, N. J. The unit, designated Presto *DA-11* tape duplicator, operates at a speed of 60 inches per second, materially reducing time required to duplicate a recorded tape. The basic *DA-11* duplicator consists of a tape reproducer to play back the master tape and a recorder which copies the playback output on new magnetic tape. A number of "slave" recorders may be fed from a single "master" reproducer.

Item 11 on the card.

"Thumb-Size" Microphone. The smallest dynamic microphone ever developed for radio and television broadcasting—a "thumb-size" Radio Corporation of America (RCA) device which weighs 2.3 ounces—was placed on the market by the broadcast and television equipment department. The miniature microphone is so small that it can be completely concealed in the hand, worn around a performer's neck, or clipped to lapel or dress. Designed for walk-around operation, the new microphone *BK-6B* promises performers greater flexibility and freedom of movement in interviews, audience participation, panel, and similar types of "off-mike" shows.

Item 12 on the card.

Transformers. A new addition to the line of oil-filled transformers designated as type *LS* has been put into production by

(*Continued on page 50A*)

For more information circle 39 on reader service card.

Types to meet every construction need:

SERV-ENS

...service entrance sleeves for fast, neat and dependable service loop connections...for all combinations of ACSR, aluminum and copper conductors.

T-TAPS

...heavy walled with extended contact areas to make stable connections under all load conditions for any combination of ACSR or aluminum and copper in sizes from 1/0 to 400 Mcm. Only two die sizes are required to install the complete range of sizes of T-Taps.

TERMINAL ADAPTERS

...eliminate problems in connecting aluminum conductors to bronze or copper terminals of equipment. The aluminum sleeve is factory bonded to a length of soft copper wire...plastic covered for greater protection.

DEAD ENDS

...standard aluminum or copper Squeezon connectors make excellent high strength, low cost dead ends at either the pole or house end of secondary lines and service drops. They are easy to install and make a much neater appearing job than other methods. Depending on the holding strength desired, from one to three Squeezons may be used. Three Squeezons in series will, in general, develop the full rated strength of copper or ACSR.

L-TAPS

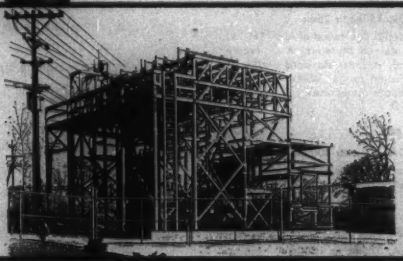
...recommended for safely connecting copper to aluminum—either line side or tap side—in locations where atmospheric contaminants will physically bridge the spacers of Squeezon connectors. The long heavy walled run section securely grips the line wire. The bore for the tap wire contains Kearnalene and is capped.

GROUND ROD SQUEEZONS

...improve circuit safety by eliminating open grounds and ground wire burn-offs caused by loose clamps. Squeezons have no screws or bolts to loosen. The dies form the fitting so that there is constant pressure on wire and rod, placing all transfer surfaces in permanent low resistance contact—safe for buried installations. The fittings are made of pure copper for highest conductivity, and forged for maximum strength.

CONNECTORS FIELD TESTED

Here at KEARNEY'S 445,000 KVA Substation Laboratory all equipment is tested under rigorous field conditions. KEARNEY Certified Ratings are actual, proved performance ratings ... not just theoretical calculations. You can be sure they will do the job they are supposed to do ... with a generous margin of safety!



312

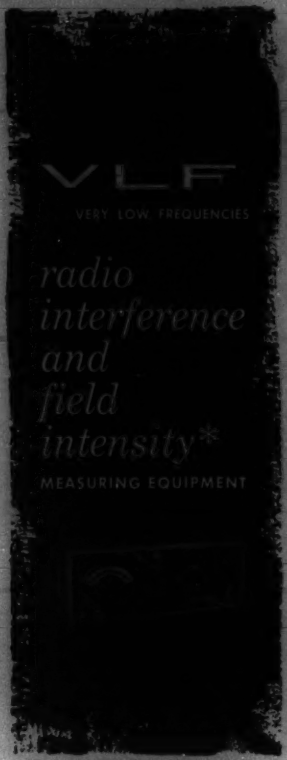
for BETTER CONSTRUCTION
SAFER MAINTENANCE

Specify

JAMES B. KEARNEY

The Mark of Quality

KEARNEY PRODUCTS



Stoddart RI-FI* meters cover the frequency range 14kc to 1000 mc

HF

NM-20B, 150kc to 25mc

Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A. C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has BFO

VHF

NM-30A, 20mc to 400mc

Commercial Equivalent of AN/URM-47. Frequency range includes FM and TV bands.

UHF

NM-50A, 375mc to 1000mc

Commercial Equivalent of AN/URM-17. Frequency range includes Citizens band and UHF color TV band.

STODDART aircraft radio co., inc.

New Products

(Continued from page 46A)

the Marcus Transformer Company of Rahway, N. J. The capacity of these units ranges from 100 kva to 5,000 kva. The rating of this transformer is 100 kva, class *OA*, 55-C rise, 1-phase, 60 cycles, 33,000 volts with 2–2½ per cent taps above and below, to 2,400/4,160 volts. This Marcus transformer features "pencil-slim" high-voltage bushings. Outstanding advances in transformer design result in a unit that is smaller not by inches, but feet.

Item 13 on the card.

Power Transistors. A new series of power transistors featuring high-power gain and uniformity of characteristics has been developed by CBS-Hytron, Division of Columbia Broadcasting System, Inc., Danvers, Mass. Four variations, offering a wide range of current gain and operating supply voltage, permit a versatility of circuit design. Efficient head dissipation is an outstanding feature of these units. A copper base, bolted to the chassis, allows the heat to flow from the power transistor to the chassis, thus providing a large area of heat radiation. A pair of *2N156*-type power transistors in a radio receiver can furnish 8.5 watts of audio power output to the loudspeaker with less than 85 milliwatts of drive power input. The *2N155*, *2N156*, *2N157*, and *2N158* types are high-power *P-N-P* germanium-alloy junction transistors, featuring uniformity of input characteristics, and excellent reliability. Their electrical characteristics include high gain at high-current levels, and low saturation currents. In addition to audio applications, they are ideally suited for use in servo amplifiers, power converters, and low-speed switching circuits.

Item 14 on the card.

Motor-Generator Sets. Fractional horsepower motor-generator sets, in frame sizes *44*, *66*, and *74*, are available from the General Electric Company's specialty component motor department, Schenectady, N. Y. Recommended as an inexpensive and reliable means of obtaining direct current from an a-c power source, the units are used as a power supply for product testing in plant laboratories, as power supply for variable-speed motors, and as self-contained exciters of larger units. They are also used to supply energy for such industrial devices as magnetic chucks. Continuous operation at rated load is made possible by a ventilating system, incorporating a fan on the shaft between units. Designated as type *LB* motor-generator sets, the compound-wound units are of dripproof ball-bearing solid-base design.

Item 15 on the card.

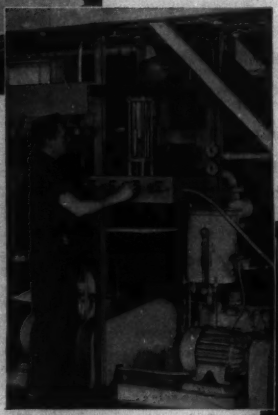
A-C Voltmeters. Standard models of expanded scale a-c voltmeters for panel mounting are now available from stock.

(Continued on page 54A)

For more information circle 42 on reader service card.

Chalmers Double Checks Insulation Quality

Utmost Dielectric Strength is Assured through use of degassed oil. Above, power factor test is made after transformer is tanked. Finally, below, completed transformer is given standard NEMA and ASA dielectric tests.



Tests Continue During Manufacture. Above: Insulation resistance tests are made on windings in oven before assembly is begun. After assembly, before it is immersed in oil, further resistance and power factor tests are made.

Oil is Degassed to secure thorough impregnation of insulation in special degassing equipment shown above. Oil is heated, sprayed into a vacuum chamber by high pressure jets which atomize it. Air dissolved in oil is then removed by low vacuum.

A-C
ALLIS-CHALMERS

CHALMERS

Announcing . . .
HYSOL 6600

An outstanding new epoxy casting resin for transformers for electronics, instrument transformers, power bushings and related equipment.

Especially Developed for
MIL-T-27A Specification

HYSOL 6600 is the result of over two years' development and evaluation in our own and government laboratories. In addition, it has been economically used in commercial transformer production with excellent results.

Write today for the HYSOL 6600 Technical Data Bulletin and samples.

PROGRESSIVE PRODUCTS THRU CHEMICAL RESEARCH
HYSOL
Product of HOUGHTON LABORATORIES, INC.

Houghton Laboratories manufactures complete lines of Electrical Insulating Materials, Adhesives and Sealants, Tooling Materials, and cast products such as rod, sheet, and tube.

FIRST IN EPOXY COMPOUNDING
HOUGHTON *LABORATORIES, INC.*
105 BUSH STREET, OLEAN, NEW YORK

New Products

(*Continued from page 50A*)

according to the Arga Division, Beckman Instruments, Inc., South Pasadena, Calif. This new voltmeter expands the useful portion of the conventional scale. Standard scales and accuracies are listed as: a-c meters read rms; maximum error caused by harmonics: 0.004-volt × volt-span × per-cent-harmonic content; a-c frequency range: 50–2,000 cycles per second; power consumption: between 1 and 2 watts, depending on span.

Item 16 on the card.

Return Spring for Solenoids. An adjustable return spring is now available on two basic models of Ledex rotary solenoids. It permits minute spring-torsion adjustments; any return spring torque can be set within the limits of the spring design. The scroll-type return spring is installed in a movable retainer ring. Fine adjustments of spring torsion are accomplished by rotating the retainer ring to the proper position, after which it is locked in place by a set screw. Mounting dimension and standard torsion-spring values are listed in a new bulletin available from G. H. Leland, Inc., 123 Webster Street, Dayton, Ohio.

Item 17 on the card.

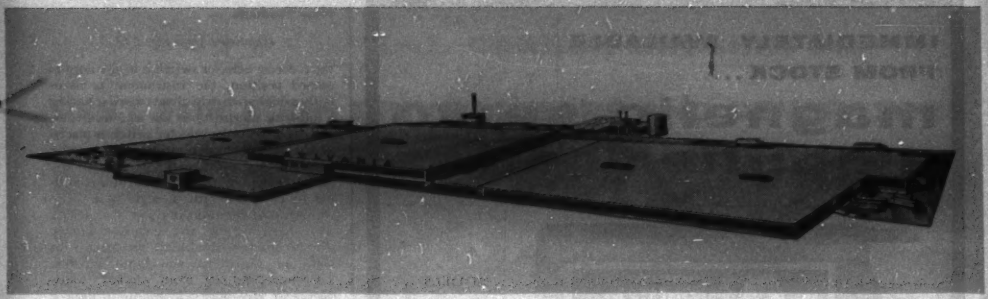
Airborne Radioactivity Recorder. The first available walk-in trailer-mounted air-monitor system with moving filter paper tape for measuring and recording airborne radioactivity has been introduced by Nuclear Measurements Corp., 2460 N. Arlington Avenue, Indianapolis, Ind. The system is designed for use by industrial plants, institutions, utilities, Government units, and research and laboratory groups, working with radioactive materials or engaged in nuclear or defense activities. This *AM-5* model operates automatically for periods from 7 to 10 days, unattended, providing a permanent continuous record of radioactivity in the area, plus complete recorded weather data, if desired. Air is drawn through a vent on top of the trailer. Radioactive particles are deposited on continuously moving filter paper in the detection chamber. The level of radioactivity is then recorded on a continuous chart. Basic detecting units of the system are a gamma-sensitive scintillation counter and a Geiger-Mueller counter, well shielded for maximum sensitivity. Nuclear Measurements Corporation also builds mobile and stationary air monitors.

Item 18 on the card.

New Ratio Recorder. The Phoenix Precision Instrument Company, Inc., Philadelphia, Pa., has announced a new recorder equipped with a dual scale: one scale, used for normal recording, is graduated 0 to 100 over the central 10 inches; the other scale, used for ratio recording, is graduated 0 to 100 over 11 inches. When

(*Continued on page 58A*)

For more information circle 45 on reader service card.



TRANSFORMERS throughout!

Shown here (left and right) are two of the four Uptegraff dry-type transformers used to provide both power and lighting current from the same distribution system, thus avoiding the duplication of units, common in the past. Two of the transformers are 750 KVA, and two are 300 KVA. All four are fed by 4160 volt circuits, and have 480Y/277 volt secondaries.

At the left is shown one of the Uptegraff dry-type transformers that provide 120-volt power. Two of these transformers are used, one being a 225 KVA unit, and the other 112½ KVA. Both have 480-volt primaries and 208Y/120 secondaries.

The photograph at the right shows how the dry-type Uptegraff transformers can be installed wherever desired, without vaults or other enclosures. This permits transformers to be safely located near the center of power usage, thus avoiding long costly runs of low-voltage circuits.

R. E. UPTEGRAFF MANUFACTURING CO. SCOTTDALE, PENNSYLVANIA

IMMEDIATELY AVAILABLE FROM STOCK...

magnetic servo amplifier series

Shown above Model MA-6-400
Actual size: 2-9/16" x 1-3/4" x 1-7/16". Wt. less than 12 oz.
Hermetically Sealed • 7-Pin Header

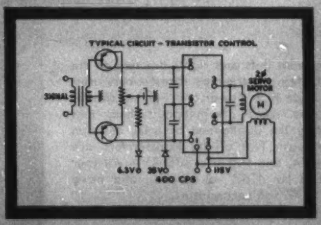
MODELS
400 cps Series

MA-3-400
MA-6-400
MA-10-400
MA-15-400
MA-18-400
MA-40-400

This complete series of precisely engineered Magnetic Servo Amplifiers is immediately available from stock, as standard components for servo systems application. Furnishes in compact form all the salient features of a high quality, hermetically sealed transformer.

OUTSTANDING PERFORMANCE CHARACTERISTICS...

- Sinusoidal Phase Reversing Output
- Transistor or Tube Control ... AC or DC Input
- Ambient Temperature Range —55°C. to +100°C.
- Low Cost, Rugged, Compact, Efficient, Long Service Life
- Meets Military Specifications



MAGNETIC SERVO AMPLIFIER SERIES

*400 cps Models**	*Applications*
MA-3-400	MK-14 (3-watt)
MA-6-400	MK-7 (6-watt)
MA-10-400	MK-8 (10-watt)
MA-15-400	16-watt
MA-18-400	18-watt
MA-40-400	40-watt

** Equivalent 60 cps Series also available*

If you are confronted with circuitry design or engineering problems involving magnetic components for servo system or other application, your inquiry directed to our engineering staff for information will receive prompt, courteous attention.

For complete technical data and performance curves... request Engineering Bulletin on Magnetic Servo Amplifier Series.

MAGNETIC RESEARCH CORP.
2070 CENTER STREET • EL SEGUNDO, CALIFORNIA

MRC

Magnetic Amplifiers • Servo Amplifiers • Magnetic Pulse Generators
Transistor DC Power Supplies • Magnetic Pulse Modulators

New Products

(*Continued from page 54A*)

the recorder selector switch is in the normal record position, the instrument is essentially a single-pen strip chart recorder having a full-scale sensitivity as low as 5 millivolts. When the recorder selector switch is placed in the ratio record position, the recorder will automatically ratio any two d-c signals, allowing a continuous ratio recording to be made with a single pen. The reciprocal of the ratio may be read at any time by reversing the recorder inputs. The recorder is capable of operating with high- or low-impedance input circuits. Therefore, outputs from electric transducers or any other electric-signal source for pressure, temperature, force, etc. may be ratioed with this recorder.

Item 19 on the card.

Radiation Analyzer. Model *1810* radiation analyzer, announced by the Nuclear Instrument and Chemical Corporation, 229 West Erie Street, Chicago, Ill., is used with a scaler or rate-meter and scintillation counter to make possible more precise measurements of gamma-emitting radioactive samples. An adjustable "window" on the analyzer may be set so that only those pulses that fall within a preselected portion of the isotope's energy spectrum are counted, thus virtually eliminating background and scattered radiation from the final count. In addition, the unit permits multiple tagging measurements and radioisotope energy analysis. The instrument, expected to find wide use in medical, biological, and industrial laboratories where gamma-emitting isotopes are used, consists of a nonoverloading linear amplifier, pulse-height discriminator, and stable high-voltage regulator. Circuitry has been designed for simplicity, extreme stability, and high reliability.

Item 20 on the card.

Multiunit Miniature Tubes. Two new general-purpose multiunit tubes of the 9-pin miniature type (*RCA-6BH8* and *RCA-6AU8*), which may be used in a wide variety of applications in black-and-white and color television receivers, have been introduced by the Radio Corporation of America's Tube Division, Harrison, N. J. Each tube embodies a medium-mu triode and a sharp-cutoff pentode in one envelope. Both types are designed with a 600-milliampere heater, having a controlled warm-up time to insure dependable performance in television receivers employing a series-heater string arrangement. The pentode units of these tubes feature individually a high transconductance value of 7,000 micromhos, and are intended for use as video amplifier tubes. They may also be used as video intermediate-frequency-amplifier tubes, as sound intermediate-frequency-amplifier tubes, or as automatic gain-controlled amplifier tubes. The triode unit of the *6BH8* has an amplification factor of 17, and is particularly suited for use in low-

(*Continued on page 60A*)

For more information circle 48 on reader service card.

NATIONAL CARBON BRUSHES ARE

BEST FOR MAIN DRIVE MOTORS AND GENERATORS

Best Because:

- "National" Brushes provide maximum commutator stability.
- "National" Brush grades are specifically designed for machine-operating characteristics.

Use These Grades:

to meet all service requirements.

- **N–4**
- **SA–45**
- **SA–35**

Here's Why:

"National" Brushes meet the widest variations in the following operating conditions.

- Current densities
- Commutator surface speeds
- Atmospheric contamination

Always consult your National Carbon Representative when selecting brushes. He is there to serve you with the best and most complete line of brushes for mill and mine operations.

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation • 30 East 42nd St., New York 17, N.Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco

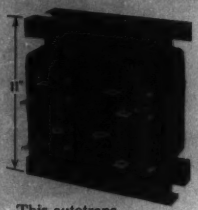
IN CANADA: Union Carbide Canada Limited, Toronto

▲ Circle 50 ▼ Circle 51 on the card.

Let Hevi Duty Help You Choose

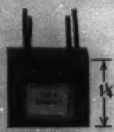
THE RIGHT SPECIALTY TRANSFORMER

This is just a small sample of the broad line of specialty transformers built by Hevi Duty Electric Company. They are available in all sizes with any desired primary or secondary voltages or frequencies. All are designed to meet or exceed NEMA standards.

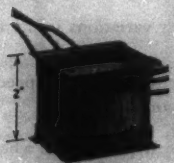


This autotransformer is used for reduced-voltage starting of synchronous and induction motors. 50, 65 and 80 percent taps are normally provided. Terminals may be mounted on the coil or leads.

Type SICB, 150 VA, 230/460-115 volts, enclosed style with a built-in thermal circuit breaker for overload protection. This compact unit saves valuable panel space.



Low-voltage pilot light transformers up to 600 V primary.



Type SIO, 10 VA, primary 110/220 volts
CONTROL WINDING — Secondary 230 volts, .032 amps, 7.4 VA
FILAMENT WINDING — Secondary 6.3 volts, .3 amps, 1.9 VA

Write for bulletins HD-499 and T-5111 or send us your requirements.

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

New Products

(*Continued from page 58A*)

frequency oscillator circuits. The triode section of the *6AU8* has an amplification factor of 40, and is intended for use in sync-separator, sync-amplifier, sync-clipper, and phase-inverter circuits. Maximum dimensions of the two tubes are identical: 2⁹/₁₆ inches high over-all, and 7/8 inches in diameter.

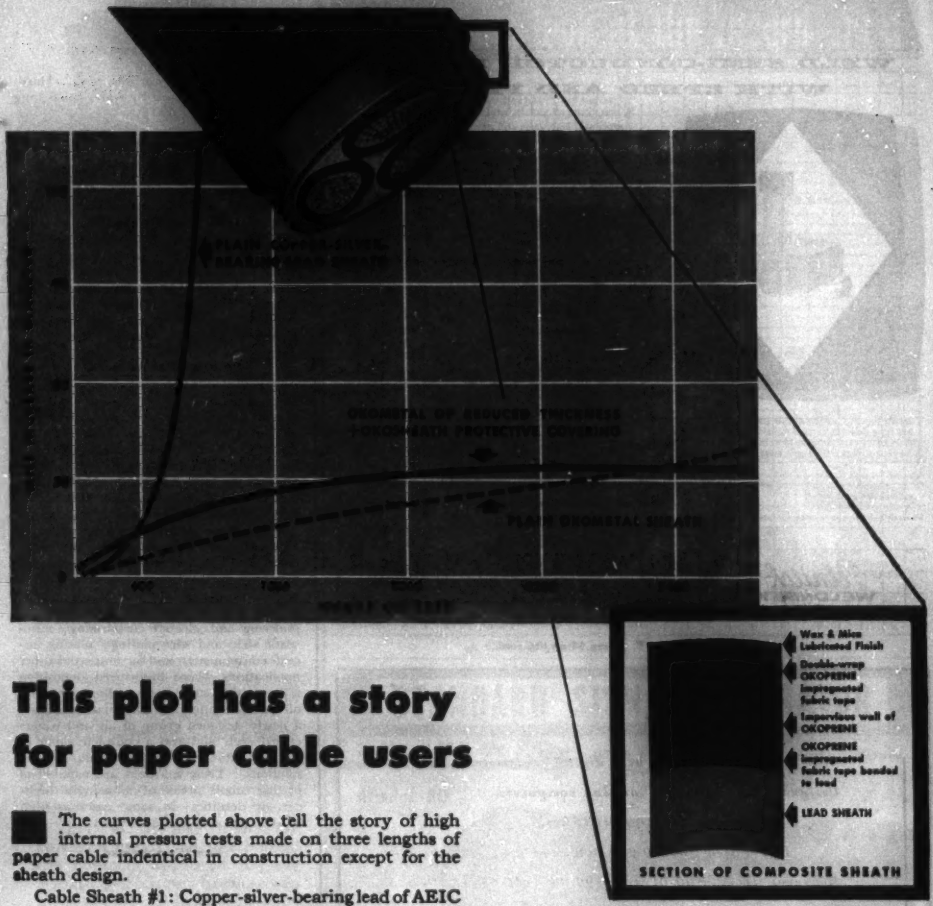
Item 21 on the card.

Analogue-Digital Converter. A lightweight 13-channel encoder has been developed by Electronics Corporation of America, Cambridge, Mass., for reading shaft positions to an accuracy of 1 part in 8,192. This instrument may be applied to a great variety of purposes, in which the position of rotating shaft is required either as an input to some controlling device or for real-time data reduction. The output of this converter is in cyclical-binary code, which may be recorded or otherwise processed in that form or converted to some other form. The converter employs no slip rings or moving contacts, no gears, and no circuits (i.e., counting) in which the accuracy of any one reading depends on that of a preceding reading. Instead, photoelectric means are employed to pick off shaft position with no frictional drag on the shaft. A glass disk is mounted directly on the shaft, and is very accurately scaled into a code of transparent and opaque areas. These areas constitute a pattern of 13 channels forming the cyclical binary code. The standard power supply weighs about 18 pounds, measures 8 × 12 × 10 inches high, can be rack-mounted, and consumes 45 watts.

Item 22 on the card.

Iron-Powder Maintenance Electrode. An iron-powder-type electrode especially for maintenance and repair welding, has been introduced by The Lincoln Electric Company, Cleveland, Ohio. The electrode, Jet-Hard *BU-90*, is for fast buildup of worn parts at low cost. It produces a medium-carbon medium-alloy deposit for building up worn parts with a dense moderately hard tough machinable surface to resist shock and abrasion. Its high deposition rate results in a 35 to 45 per cent increase in the amount of metal deposited per minute, compared with conventional build-up electrodes. Slag is practically self-removing. The arc is smooth with minimum spatter and is easy to control. Chromium carbide in the deposit produces abrasion resistance 25 to 50 per cent greater than that of deposits made with conventional high-carbon build-up electrodes. Impact resistance and toughness is increased by both chromium and manganese in the deposit. The hardness range runs from 27 to 40 Rockwell *C* under normal welding conditions. Exact values depend upon the alloy content of the steel welded and the cooling rate of the weld. Deposits made with normal procedures are machinable

(*Continued on page 62A*)


Wax & Mica Lubricated Finish
Double-wrap OKOPRENE Impregnated fabric tape
Impervious wall of OKOPRENE
OKOPRENE Impregnated fabric tape bonded to lead
LEAD SHEATH
SECTION OF COMPOSITE SHEATH

This plot has a story for paper cable users

The curves plotted above tell the story of high internal pressure tests made on three lengths of paper cable indentical in construction except for the sheath design.

Cable Sheath #1: Copper-silver-bearing lead of AEIC recommended thickness

Cable Sheath #2: Okometal alloy of AEIC recommended thickness

Cable Sheath #3: Composite design with Okometal alloy of two-thirds AEIC thickness plus Okosheath Protective Covering

Sheath #1, having the least resistance to internal pressure, started to "neck down" or thin-out at one spot, which led to a rapidly increasing expansion and failure after only 1152 hours on test. Sheath #2, made with unprotected Okometal of full AEIC thickness, was still on test after 6000 hours, indicating its superiority over a conventional lead sheath. Composite sheath #3, made with Okometal of reduced thickness but having an Okosheath Protective Covering, was not only still on test after 6000 hours, but also showed a flat curve that indicated the highest degree of stability with no tendency to "neck down."

Along with the advantages disclosed above, the composite sheath construction of Okometal plus Okosheath Protective Covering possesses superior resistance to scoring during installation and eliminates both chemical and electrolytic corrosion. These features are fully discussed in Bulletin EG-1047, available upon request from The Okonite Company, Passaic, New Jersey.

Available with either copper or aluminum conductors

OKONITE OKONITE SINCE 1878 ***insulated cables***

WELD SEMI-CONDUCTOR DEVICES
WITH SPEED AND PRECISION
whisker-wire
welded directly
to lead or stud
precision stored-energy welding
WELDMATIC MODEL 1015 welds molybdenum, tungsten, gold, iridium-platinum, or other fine wire to Dumet, Kovar, steel, etc. Diameters 0.0003 to 0.060 inch welded easily without oxidation or annealing
Unitek WELDMATIC
UNITEK CORPORATION
253 Halstead Avenue • Pasadena 8, California
Write for Complete Technical Information on Stored Energy Welding

▲ Circle 53 ▼ Circle 54 on the card.

NON-LINEAR SYSTEMS new digital voltmeter--Model 450.
Designed especially for analog computers.
Uses oil-immersed stepping switches,
life-tested for 20,000,000 readings.
Measures from ±00.01 to ±99.99 volts d-c.
Presents in-line, luminous display.

write for bulletin 240

NON-LINEAR SYSTEMS, INC.
Del Mar Airport
Del Mar, California

New Products

(*Continued from page 60A*)

with high-speed or carbide tools. Hardness can be increased by water quenching the deposit from 1,600 F.

Item 23 on the card.

Power Capacitor. A new 50-reactive-kilovolt-ampere (kvar) power capacitor for voltages from 2,400 to 7,960 volts is available. Designed to permit utilities to place more capacity on limited pole space, the new units have a lower installation cost per kvar, and provide more kvar capacity per pound. The new capacitors retain the solder-sealed bushing and the zinc-spray finish used on previous units.

Item 24 on the card.

Localized Plating. A new and highly advanced method, "The Dalic Process," for localized and selective electroplating is now available from Marlene Development Company, Inc., 153 East 26th Street, New York, N. Y. The Dalic Process has been extensively used for a number of years by many of the major industries in England and Europe. Applications include build-up and repair of worn components; electroplating of selected areas of electric contacts and electronic parts; plating of plastic-metal combinations; soldering and selective carburizing; automatic strip and wire plating; plating aircraft components; and for numerous other applications where high-speed deposition is required on small areas without stopping-off or dismantling. Dalic plating utilizes a newly designed group of air and water-cooled styli and also a complete range of special nontoxic nonfuming metallo-organic solutions. These solutions are capable of plating small areas of amazingly high-current densities—in some cases as high as 6,000 amperes per square foot.

Item 25 on the card.

TRADE LITERATURE

Companion Stresses Need for Safe and Adequate Wiring for Appliances. In a four-page editorial feature "Are You Wired for Modern Living?" the January issue of the Woman's Home Companion tells home owners how to find out if their house wiring is safe and adequate. The article, geared to the woman's point of view, points out the 24 electrical appliances which have gained good acceptance since 1940. The capacity to handle these appliances is discussed in detail with positive suggestions to aid housewives in obtaining adequate wiring to operate an efficient electrical home properly. In co-operation with the National Adequate

(*Continued on page 66A*)

PLAY VITAL ROLE

IN NEW EQ-P

CIRCUIT BREAKER

Compact design of the new EQ-P type circuit breaker introduced by I-T-E now provides compact plug-in lighting panelboards. A factor in making possible this compactness was the smaller, more efficient Gibson electrical contacts developed to do the job in this tiny single-pole breaker.

In fact, the contacts are an important part of the story.

The problem: to develop small contacts that would withstand a 5,000-ampere short circuit test, maintain low temperature rise, have high interrupting rating, keep contact resistance low, and never need attention. Special Gibsiloy silver-tungsten contacts were tested and approved by I-T-E for the EQ-P breaker. These Gibsiloys were outstanding in every way.

The same 23-year Gibson experience and knowledge behind the contacts approved for the I-T-E EQ-P circuit breaker can be put to the test in solving many other electrical problems involving contacts. Consult Gibson engineers when developing new products or improving old ones. It will pay you to do so.

Write for Gibson Catalog C-520. It contains much useful technical data on electrical contacts. No obligation.

CONTACT GIBSON FIRST

Gibsiloy
ELECTRICAL CONTACTS

GIBSON ELECTRIC COMPANY

8348 Frankstown Avenue, Pittsburgh 21, Pa.

Circle 57 on the card

Let's take a look at the record—first

In specifying capacitors may we suggest you do just that . . . Take a look at the Record.

Here is proof-positive you should have before making commitments to purchase capacitors.

Reproduced on the right is an actual life test record of a group on test since August 3, 1947, a period of over 8 years.

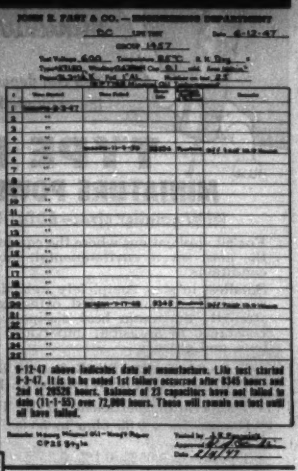
This represents only one of thousands of such tests made for more than 20 years—not occasionally—but year in and year out, twenty-four hours of every day.

While it is hardly necessary to remind you this is an expensive procedure—you cannot build *reliability* into a capacitor by specifications alone or be assured of it by ordinary accelerated life tests. (Terminated after 250 hours, for example.)

Reliability can only be established through designs based on the knowledge acquired from many long time tests of large group sizes such as we carry on—these are the only alternative. Cost in this respect is secondary as recovery of this added expense comes through less failures in the field.

When you have a capacitor requirement . . . Take a look at the Record . . . *first*. Specify FAST—The only capacitor with a "Proven Pedigree."

We are presently the only capacitor manufacturer qualified under the Signal Corps Reduced Inspection Quality Assurance Program. (RIQAP)


JOHN E. FAST & CO. — ENGINEERING DEPARTMENT

D.C. LIFE TEST — Date 6-12-47

GROUP 1947

#	Time Started	Time Failed	Life	Cum. Life	Remarks
1	8-3-47				
2	"				
3	"				
4	"				
5	"	11-5-47	8345	Duplicate	2nd Fail 10-3 Hours
6	"				
7	"				
8	"				
9	"				
10	"				
11	"				
12	"				
13	"				
14	"				
15	"				
16	"				
17	"				
18	"				
19	"				
20	"	2-17-48	8345	Duplicate	2nd Fail 10-3 Hours
21	"				
22	"				
23	"				
24	"				
25	"				

9-12-47 above indicates date of manufacture. Life test started 8-3-47. It is to be noted 1st failure occurred after 8345 hours and 2nd at 29520 hours. Balance of 23 capacitors have not failed to date (11-1-55) over 72,000 hours. These will remain on test until all have failed.

Remarks: Missing Terminal #24—Rough Paper CP25 $9\frac{1}{16}$

Tested by A.P. Fitzpatrick

Approved [signature]

Date 8/14/47

JOHN E. FAST & CO.

Capacitor Specialists For Over A Third of A Century

3169 North Pulaski Road, Chicago 41, Ill.

"WHEN YOU THINK OF CAPACITORS . . . THINK FAST"

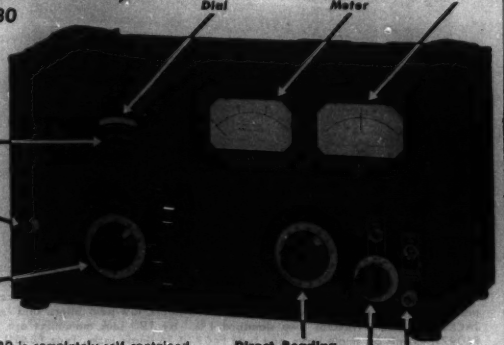
AVAILABLE LITERATURE:
Polystyrene Film Capacitors
Hermetically-Sealed Tubular Capacitors
Subminiature Hermetically-Sealed Capacitors
High-Reliability Hermetically-Sealed Capacitors
Mil-C-25A Approved Capacitors: Refer to "Mil-C-25A Specifications"
Power-Factor Correction Capacitors and Racks

▲ Circle 58 on the card ▼ Circle 59 on the card

STANDARD SIGNAL GENERATOR

2 Mc. - 400 Mc.

Model 80



The MODEL 80 is completely self-contained, with built-in power supply and modulator. An extremely stable and accurate instrument for laboratory use, production testing or servicing.

Complete data on request

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BOONTON NEW JERSEY

DALOHM
Ω
TYPE RS
MINIATURE POWER RESISTORS
NEW smaller sizes—ADDITIONAL wattage range
For all applications where the equipment must survive the most severe environmental, shock, and vibration conditions.
Smallest in size; completely welded from terminal to terminal; silicone sealed, offering high di-electric strength, maximum heat dissipation, and maximum resistance to abrasion; impervious to moisture, salt ions, and gases.
RS-2A, 2 watts; RS-2B, 2 watts; RS-2, 2 watts; RS-5, 5 watts; RS-7, 7 watts; RS-10, 10 watts.
• Temperature coefficient 0.00002/Deg. C
• Ranges from 0.05 ohm to 55,000 ohms, depending on type
• Tolerances 0.05%, 0.1%, 0.25%, 0.5%, 1%, 3%, 5%
Conform to applicable JAN and MIL Specifications
Write for Bulletin R-23A
Export Dept
Pan-Mar Corp
1270 Broadway
New York 1, N.Y.
In Canada
Charles W. Pointon, Ltd
6 Alcina Ave., Toronto

▲ Circle 60 ▼ Circle 61 on the card.

COMPONENTS FOR COMMUNICATION SYSTEMS

Radio Engineering Products produces a wide range of standard components for use in communication systems. In most cases these components can be delivered from stock.
FILTERS: Filters of advanced design are available for carrier telegraph, carrier telephone, and telemetering systems. These include channel filters, low-pass filters, and line filters.
JACKS and MOUNTINGS: Two standard 1¾" by 19" jack mountings are available. Type F6097A mounts 52 single jacks, and type F6097B 26 single jacks. Type F8410 jack is a double jack with parallel break contacts, interchangeable with type 410A.
REPEATING and RETARDATION COILS: A large number of standard types are carried in stock. These include voice-frequency and carrier-frequency line coils, hybrid coils, and retard coils for telephone and telegraph applications.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE UNiversity 6-6887
CABLES RADENPRO MONTREAL

Trade Literature

(*Continued from page 62A*)

Wiring Bureau, reprints of the editorial feature have been made available to electric power companies for promotion at the local level.

Standard Conversion Tables. A new Wheelco bulletin, "Standard Conversion Tables," *F7255*, gives thermocouple temperature-millivolt equivalents. Temperatures are expressed on the International Temperature Scale of 1948. The electromotive force is expressed in absolute units. Instrument men will find this particular item of literature convenient reference material.

SMPTE Wide Screen Booklet. A booklet describing several new methods of motion picture production and exhibition that came into use during and after 1952 has been published by the Society of Motion Picture and Television Engineers (SMPTE). Aimed at giving a comprehensive yet easily understood outline of present day techniques and the ways in which they differ from those that became "standard" during the late 1920's the booklet makes no attempt to evaluate systems. Copies of the booklet are available at SMPTE headquarters, 55 West 42d Street, New York, N. Y.

Bakelite Plastics and Resins. A new, revised, "1956 Condensed Reference File of Bakelite Plastics and Resins" presents the latest information about properties and uses of these materials supplied by Bakelite Company, a Division of Union Carbide and Carbon Corporation. This 12-page booklet summarizes technical data about the wide range of special and general-purpose Bakelite phenolic, vinyl, styrene, polyethylene, fluorothene, polyester, silicone, and epoxy plastics and resins, and Krene film and sheeting. Copies of the booklet are available to firms who send requests to Bakelite Company, Division of Union Carbide and Carbon Corporation, 300 Madison Avenue, New York, N. Y.

New Brochure Details Industrial Uses of Tape. Properties, specifications, and applications data on its complete line of pressure-sensitive tapes have been compiled in a 25-page brochure by Behr-Manning, Division of Norton Company, Troy, N. Y. In text, table, and illustration, "Tape It with Behr-Cat" covers scores of industrial applications and includes helpful tips on how to determine tape quality, and how to specify the proper tape for the job at hand. Copies are available without charge on request to Behr-Manning, Troy, N. Y.

Laminations Catalogue Issued. Magnetics, Inc., Butler, Pa., has issued a greatly expanded laminations catalogue, describing the company's standard lines of laminations, laminated cores, and dies. Cat-

(*Continued on page 68A*)

...a little longer...

by A-MP ... solution for ... aluminum wire termination

No galvanic action . . . oxidation is inhibited . . . full rated conductivity is assured . . . by using A-MP's all aluminum Termalum Terminals. The distinguishing features are the cartridge, containing abrasive inhibitor compound, and the specially-designed symmetrical "C" crimp. Under pressure of the crimp the compound abrades oxide from the wire and prevents it from reforming. The cartridge is closed with a removable plastic plug that is color-coded for wire size identification. The entire terminal is tin-plated by a special process to assure high conductivity and corrosion resistance.

TERMALUM

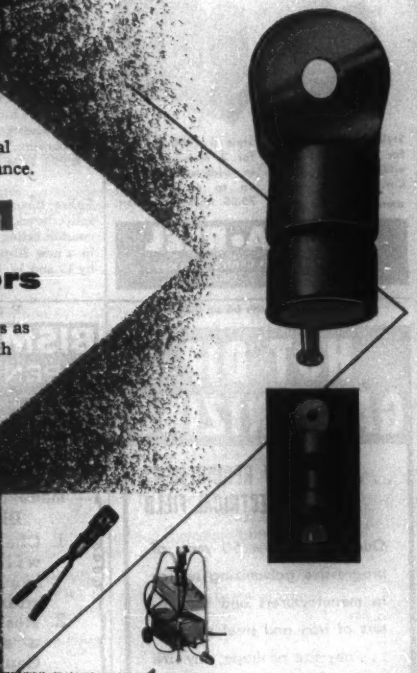
Trade mark

terminals and connectors

Copalum* Terminals and Connectors have the same features as Termalum except that the body-tongue is made of copper. With this design, smaller tongues are permissible. Precautions usually taken with aluminum terminals when connecting to copper busses can be eliminated. Termalum and Copalum Terminals and Connectors exceed all military specifications.

A-MP Termalum and Copalum Terminals are applied with A-MP Dyna-Crimp* Power Tools and Hand- or Foot-operated Hydraulic Tools. Dyna-Crimp Tooling is available for bench mounting or with a portable cart.

Write for additional information on these products.



A-MP

AIRCRAFT-MARINE PRODUCTS, INC.

Harrisburg, Pa.

A-MP of Canada, Ltd., Toronto, Canada
A-MP—Holland N.V., 's-Hertogenbosch, Holland
Aircraft-Marine Products (G.B.) Ltd., London, England
Societe A-MP de France, Courbevoise, Seine, France

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For more information circle 62 on reader service card.

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Style A 2,000 lbs. cap. for reels up to 28 in. wide. 37.50 f. o. b. Cincinnati.
Style B 4,000 lbs. cap. for 2 reels up to 24 in. wide each or 1 reel up to 48 in. wide. 75.00 f.o.b. Cincinnati.
WRITE FOR DETAILS TODAY
ROLL-A-REEL
1100 Sycamore at Central Parkway
Cincinnati 2, Ohio

Trade Literature

(Continued from page 68A)

logue *ML 201*, "Performance Guaranteed Magnetic Laminations," includes specification sheets of individual laminations to actual scale and weights and counts for different materials. Provision is made for additional data as it becomes available. Sections are devoted to laminated core assemblies, mechanical and magnetic parameters, and lamination tolerances. Copies may be obtained by writing to the company.

Triplex Service Drops. Complete information on aluminum triplex service drops is included in a new booklet issued by Kaiser Aluminum and Chemical Corporation. The 20-page illustrated publication discusses the various types and sizes of triplex available from the company, tabulates cost comparisons, cites advantages, and discusses methods of dead-ending and connector selecting. In a separate section specific equations on cost, efficiency, and related information are answered. The booklet may be obtained from Kaiser Aluminum and Chemical Corporation's Industrial Service Division *PR 255*, 1924 Broadway, Oakland, Calif.

Splice Boxes Bulletin. Various types of splice boxes, with and without armor and conduit fitting are described and illustrated in a new 20-page bulletin, *BB55*, released by G and W Electric Specialty Company. In addition, the bulletin shows different types of secondary and primary sectionalizing boxes, air and oil filled. Copies of the bulletin are available on request by writing G and W Electric Specialty Company, 7780 Dante Avenue, Chicago, Ill.

Powder Metallurgy. An 18-page bulletin on powder metallurgy has been published by Keystone Carbon Company. Sections include a summary of the powder metallurgy process, designing for powder metallurgy, typical applications, and details on the facilities and capacity of the company. Highlights of the publication are the physical characteristics and chemical compositions of a number of ferrous and nonferrous production materials. Copies of the bulletin may be obtained from Keystone Carbon Company, St. Marys, Pa.

Stoddart Bulletin. A 37-page bulletin "Measurement of Radio Interference in Accordance with Specification MIL-I-6181B" is available from the Stoddart Aircraft Radio Company, Inc., clarifying certain portions of the United States Air Force and Navy Bureau of Aeronautics specification *MIL-I-6181B*. The bulletin describes the application of radio interference; field intensity measuring equipment in accordance with *MIL-I-6181B*. Specific instructions and practical examples are cited, including a perspective illustration of a typical equipment setup. An appendix to this bulletin includes data on bandwidth concepts in interference measuring equipment. This valuable bulletin is available at no cost from the Stoddart Aircraft Radio Company, Inc., 6644 Santa Monica Boulevard, Hollywood, Calif.

Catalogue Available on Oscillographic Recording Equipment. All Sanborn *150* series oscillographic recording systems, components, and associated equipment are fully described in a new 16-page illustrated catalogue recently published. Basic *150* systems, in 1-, 2-, 4-, 6-, and 8-channel models, as well as the 11 currently available plug-in preamplifiers, are described in detail. Performance data as well as frequency response characteristics of galvanometer with driver amplifier, are also provided. Technical details are included on the Sanborn model *150-1900* master oscillator power amplifier and model *150-300/700* wide band driver amplifier and power supply. Copies are available on request from Sanborn Company, Industrial Division, 195 Massachusetts Ave., Cambridge, Mass.

Switchboards with Basic Circuits. General Electric's "building block" concept as applied to switchboards is described in a new 4-color 40-page bulletin "Switchboards with Basic Circuits." The publication shows how eight classifications of standard switchboards are constructed, operated, and tested. A complete discussion of basic circuit specifications in duplex switchboard is included. Requests for the bulletin, designated *GEA-4127B* should be addressed to the General Electric Company, Schenectady, N. Y.

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